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GATE SOLVED PAPER - EE

2014-3

General Aptitude

Q. 1 - Q. 5 Carry one mark each.

Q. 1 While trying to collect (I) an envelope from under the table (II), Mr. X fell down (III) and was losing consciousness (IV)

Which one of the above underlined parts of the sentence is NOT appropriate ?

(A) I (B) II

(C) III (D) IV

Sol. 1 Correct option is (D).

IV underlined part is not correct. The correct statement for the IV underline part will be 'lost consciousness'.

Q. 2 If she _ _ _ _ how to calibrate the instrument, she _ _ _ _ _ done the experiment.

(A) knows, will have (B) knew, had

(C) had known, could have (D) should have known, would have

Sol. 2 Correct option is (C).

For a conditional sentence, the rule is as given below.

If + past perfect tense

Would/could have + past participles.

Thus, the complete sentence is

If she had known how to calibrate the instrument, she could have done the experiment.

Q. 3 Choose the word that is opposite in meaning to the word "coherent".

(A) sticky (B) well-connected

(C) rambling (D) friendly

Sol. 3 Correct option is (C)

Coherent – capable of thinking and expressing yourself in a clear and consistent manner. rambling – spreading out in different directions or distributed irregularly.

Sticky – covered with an adhesive material.

So, coherent and rambling are opposite to each other.

Q. 4 Which number does not belong in the series below ?

2, 5, 10, 17, 26, 37, 50, 64

(A) 17 (B) 37

(C) 64 (D) 26

Sol. 4 Correct option is (C).

2, 5, 10, 17, 26, 37, 50, 64

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The difference between successive terms is in AP with initial term 3 and the common difference 2. With this logic 64 is the wrong term and the correct number in place of 64 is 65.

Q. 5 The table below has question-wise data on the performance of students in an examination. The marks for each question are also listed. There is no negative or partial marking in the examination.

Q. No.	Marks	Answered Correctly	Answered Wrongly	Not Attempted
1	2	21	17	6
2	3	15	27	2
3	2	23	18	3

What is the average of the marks obtained by the class in the examination ?

(A) 1.34 (B) 1.74

(C) 3.02 (D) 3.91

Sol. 5 Correct option is (C).

$$\text{Total students in class} = 44$$

$$\text{Total marks scored by class} = 21 \times 2 + 15 \times 3 + 23 \times 2$$

$$= 42 + 45 + 46$$

$$= 133$$

$$\text{Average marks} = \frac{\text{Total marks}}{\text{Total students}}$$

$$= \frac{133}{44}$$

$$= 3.02$$

Q. 6 - Q. 10 Carry two marks each.

Q. 6 A dance programme is scheduled for 10.00 a.m. Some students are participating in the programme and they need to come an hour earlier than the start of the event. These students should be accompanied by a parent. Other students and parents should come in time for the programme. The instruction you think that is appropriate for this is

(A) Students should come at 9.00 a.m. and parents should come at 10.00 a.m.

(B) Participating students should come at 9.00 a.m. accompanied by a parent, and other parents and students should come by 10.00 a.m.

(C) Students who are not participating should come by 10.00 a.m. and they should not bring their parents. Participating students should come at 9.00 a.m.

(D) Participating students should come before 9.00 a.m. Parents who accompany them should come at 9.00 a.m. All others should come at 10.00 a.m.

Sol. 6 Correct option is (B).

(i) Dance program is scheduled for 10 a.m.

(ii) Participating student should come at 9 a.m. accompanied by a parent.

(iii) non-participating student should come at 10 a.m. with their parents.

Combining these three instructions (B) option is most appropriate.

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Q. 7 By the beginning of the 20^{th} century, several hypotheses were being proposed, suggesting a paradigm shift in our understanding of the universe. However, the clinching evidence was provided by experimental measurements of the position of a star which was directly behind our sun. Which of the following inference(s) may be drawn from the above passage ?

(i) Our understanding of the universe changes based on the positions of stars

(ii) Paradigm shifts usually occur at the beginning of centuries

(iii) Stars are important objects in the universe

(iv) Experimental evidence was important in confirming this paradigm shift

(A) (i), (ii) and (iv) (B) (iii) only

(C) (i) and (iv) (D) (iv) only

Sol. 7 Correct option is (D).

(i) Clinching evidence was provided by experimental measurement of position of star.

(ii) Our understanding of universe changes, so experimental evidence are important.

So, by these (iv) is correct option.

Q. 8 The Gross Domestic Product (GDP) in Rupees grew at 7% during 2012-2013. For international comparison, the GDP is compared in US Dollars (USD) after conversion based on the market exchange rate. During the period 2012-2013 the exchange rate for the USD increased from Rs. 50/ USD to Rs. 60/USD. India'a GDP in USD during the period 2012-2013.

(A) increased by 5% (B) decreased by 13%

(C) decreased by 20% (D) decreased by 11%

Sol. 8 Correct option is (D).

Let GDP in 2011-12 be x

GDP in 2012-13 is $1.07x$ (7% grew)

During 2012-13 exchange rate increase from Rs. 50/USD to Rs.60/USD.

So, GDIP in comparison to USD is obtained as

$$\text{at initial of 2012-13 GDP/USD} = \frac{x}{50}$$

$$\text{and at final 2012-13 GDP/USD} = \frac{1.07x}{60}$$

So,
$$\text{increase and decrease} = \frac{\frac{1.07x}{60} - \frac{x}{50}}{\frac{x}{50}} \times 100\%$$

$$= 10.83\%$$

$$= 11\%$$

Q. 9 The ratio of male to female students in a college for five years is plotted in the following line graph. If the number of female students in 2011 and 2012 is equal, what is the ratio of male students in 2012 to male students in 2011 ?

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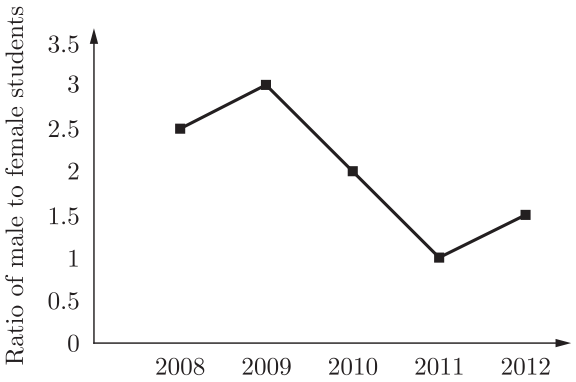

(A) 1 : 1 (B) 2 : 1

(C) 1.5 : 1 (D) 2.5 : 1

Sol. 9 Correct option is (C).

Let number of female students in 2011 be x.

So, Number of male students in 2011 $= x$ (ratio is 1)

Number of female students in 2012 $= x$ (Given)

Number of male students in 2012 $= 1.5x$ (ratio is 1.5)

Ratio of male students in 2012 to male students in 2011 is

$$= \frac{1.5x}{x} = 1.5:1$$

Q. 10 Consider the equation $(7526)_8 - (Y)_8 = (4364)_8$, where $(X)_N$ stands for X to the base N. Find Y.

(A) 1634 (B) 1737

(C) 3142 (D) 3162

Sol. 10 Correct option is (C).

Given equation is

$$(7526)_8 - (Y)_8 = (4364)_8$$

or $$(Y)_8 = (7526)_8 - (4364)_8$$

Octal subtraction is done in same way as decimal subtraction. The only difference is that while obtaining carry we get 8 instead of 10.

$$\begin{array}{r} (7526)_8 \\ -(4364)_8 \\ \hline (3142)_8 \end{array}$$

END OF THE QUESTION PAPER

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Electrical Engineering

Q. 1 - Q. 25 Carry one mark each.

Q. 1 Two matrices A and B are given below :

$$A = \begin{bmatrix} p & q \\ r & s \end{bmatrix};\ B = \begin{bmatrix} p^2+q^2 & pr+qs \\ pr+qs & r^2+s^2 \end{bmatrix}$$

If the rank of matrix A is N, then the rank of matrix B is

(A) $N/2$ (B) $N-1$

(C) N (D) $2N$

Sol. 1 Correct option is (C).

Given the two matrices,

$$A = \begin{bmatrix} p & q \\ r & s \end{bmatrix}$$

and

$$B = \begin{bmatrix} p^2+q^2 & pr+qs \\ pr+qs & r^2+s^2 \end{bmatrix}$$

To determine the rank of matrix A, we obtain its equivalent matrix using the operation, $a_{2i} \leftarrow a_{2i} - \frac{a_{21}}{a_{11}} a_{1i}$ as

$$A = \begin{bmatrix} p & q \\ 0 & s - \frac{r}{p}q \end{bmatrix}$$

If

$$s - \frac{r}{p}q = 0$$

or

$$ps - rq = 0$$

then rank of matrix A is 1, otherwise the rank is 2.

Now, we have the matrix

$$B = \begin{bmatrix} p^2+q^2 & pr+qs \\ pr+qs & r^2+s^1 \end{bmatrix}$$

To determine the rank of matrix B, we obtain its equivalent matrix using the operation, $a_{2i} \leftarrow a_{2i} - \frac{a_{21}}{a_{11}} a_{1i}$ as

$$B = \begin{bmatrix} p^2+q^2 & pr+qs \\ 0 & (r^2+s^2) - \frac{(pr+qs)^2}{p^2+q^2} \end{bmatrix}$$

If

$$(r^2+s^2) - \frac{(pr+qs)^2}{p^2+q^2} = (ps-rq)^2 = 0$$

or

$$ps - rq = 0$$

then rank of matrix B is 1, otherwise the rank is 2.

Thus, from the above results, we conclude that

If $ps - rq = 0$, then rank of matrix A and B is 1.

If $ps - rq \neq 0$, then rank of A and B is 2.

i.e. the rank of two matrices is always same. If rank of A is N then rank of B also N.

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Q. 2 A particle, starting from origin at $t = 0\,\text{s}$, is traveling along x-axis with velocity

$$v = \frac{\pi}{2}\cos\left(\frac{\pi}{2}t\right)\text{m/s}$$

At $t = 3\,\text{s}$, the difference between the distance covered by the particle and the magnitude of displacement from the origin is _ _ _ _ _ _.

Sol. 2 Correct answer is (C).

Given the velocity of particle,

$$v = \frac{\pi}{2}\cos\frac{\pi t}{2}$$

Since, the velocity of the particle is along x-axis. So, we have

$$v = \frac{dx}{dt}$$

Therefore, the displacement of the particle from $t = 0$ (origin) to $t = 3$ is

$$x = \int_{t=0}^{t=3} v\,dt = \int_{t=0}^{t=3} \frac{\pi}{2}\cos\frac{\pi}{2}t\,dt$$

$$= \left[\sin\tfrac{\pi}{2}t\right]_0^{\pi=3}$$

$$= -1$$

or $$|x| = 1$$

i.e. the magnitude of displacement is 1.

Now, we have to determine the distance covered by the particle. For calculating distance, we have to consider speed and speed can't be negative, so the distance is given by

$$x_0 = \int_{t=0}^{t=3} |v|\,dt$$

$$= \int_{t=0}^{t=3} \left|\frac{\pi}{2}\cos\frac{\pi}{2}t\right|dt$$

$$= \int_{t=0}^{t=1} \frac{\pi}{2}\cos\frac{\pi}{2}t - \int_{t=1}^{t=3} \frac{\pi}{2}\cos\frac{\pi}{2}t\,dt$$

$$= \left[\sin\frac{\pi}{2}t\right]_{t=0}^{1} - \left[\sin\frac{\pi}{2}t\right]_{t=1}^{t=3}$$

$$= 1 - (-1 - 1)$$

$$= 3$$

Thus, the difference between the distance covered and magnitude of displacement is

$$\Delta x = x_0 - |x| = 3 - 1 = 2$$

Q. 3 Let $\nabla \cdot (f\,v) = x^2y + y^2z + z^2x$, where f and v are scalar and vector fields respectively. If $v = yi + zj + xk$, then $v \cdot \nabla f$ is

(A) $x^2y + y^2z + z^2x$ (B) $2xy + 2yz + 2zx$

(C) $x + y + z$ (D) 0

Sol. 3 Correct option is (A).

Given the relation

$$\nabla \cdot (fv) = x^2y + y^2z + z^2x \quad \text{...(i)}$$

where f, v are scalar and vector field respectively. From the properties of vector field, we have

$$\nabla \cdot (fv) = v \cdot (\nabla f) - f(\nabla \cdot v)$$

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or $$v \cdot (\nabla f) = \nabla \cdot (fv) + f(\nabla \cdot v) \quad \text{...(ii)}$$

Again, we have

$$v = yi + zj + xk$$

So, $$\nabla \cdot v = \frac{\partial y}{\partial x} + \frac{\partial z}{\partial y} + \frac{\partial x}{\partial z}$$

$$= 0$$

Therefore, we get

$$f(\nabla \cdot v) = 0$$

Substituting it in equation (ii), we get

$$v \cdot (\nabla f) = \nabla \cdot (fv)$$

Thus, $$v \cdot (\nabla f) = x^2y + y^2z + z^2x \quad \text{[from equation (i)]}$$

Q. 4 Lifetime of an electric bulb is a random variable with density $f(x) = kx^2$, where x is measured in years. If the minimum and maximum lifetimes of bulb are 1 and 2 years respectively, then the value of k is _____.

Sol. 4 Correct answer is 0.43.

Given that the life time of an electric bulb is a random variable with density,

$$f(x) = kx^2.$$

where x is the lifetime measured in years.

From the property of random variable, we have

$$\int_{-\infty}^{\infty} f(x)dx = 1$$

Since, the minimum and maximum lifetimes of bulbs are 1 and 2 years respectively. So, we have

$$1 \le x \le 2$$

Therefore, equation (i) becomes

$$\int_1^2 f(x)dx = 1$$

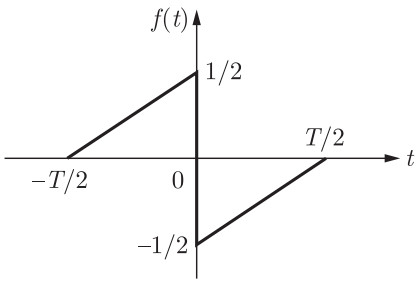
or $$\int_1^2 kx^2 dx = 1$$

or $$k\left[\frac{x^3}{3}\right]_1^2 = 1$$

or $$k\left(\frac{8-1}{3}\right) = 1$$

Thus, $$k = \frac{3}{7} = 0.43$$

Q. 5 A function $f(t)$ is shown in the figure.



The Fourier transform $F(\omega)$ of $f(t)$ is

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(A) real and even function of ω

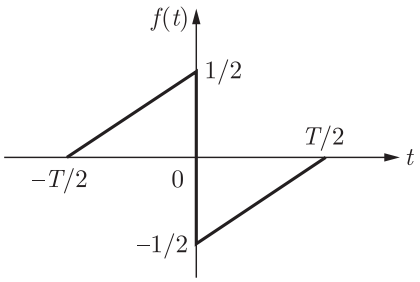
(B) real and odd function of ω

(C) imaginary and odd function of ω

(D) imaginary and even function of ω

Sol. 5 Correct option is (A).

We have the waveform of function $f(t)$ as



From the waveform, we observe that $f(t)$ is an odd function, i.e.

$$f(-t) = -f(t)$$

Hence, the Fourier transform of the function is imaginary.

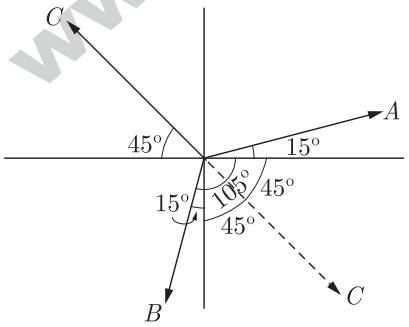
Q. 6 The line A to neutral voltage is $10\angle 15^\circ$ V for a balanced three phase star connected load with phase sequence ABC. The voltage of line B with respect to line C is given by

(A) $10\sqrt{3}\angle 105^\circ$ V (B) $10\angle 105^\circ$ V

(C) $10\sqrt{3}\angle -75^\circ$ V (D) $-10\sqrt{3}\angle 90^\circ$ V

Sol. 6 Correct option is (C).

We sketch the phasor diagram for three phase star connected load as



Since, line A to neutral voltage is

$$A = 10\angle 15^\circ \text{ V}$$

So, for balance 3-phase, we have

$$B = 10\angle -105^\circ$$

and

$$C = 10\angle -225^\circ$$

Therefore, the voltage of line B with respect to line C is

$$\begin{aligned} v_{BC} &= v_B - v_C \\ &= 10\angle -105^\circ - 10\angle -225^\circ \\ &= 10\sqrt{3}\angle -75^\circ \end{aligned}$$

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Q. 7 A hollow metallic sphere of radius r is kept at potential of 1 Volt. The total electric flux coming out of the concentric spherical surface of radius $R(> r)$ is

(A) $4\pi\varepsilon_0 r$ (B) $4\pi\varepsilon_0 r^2$

(C) $4\pi\varepsilon_0 R$ (D) $4\pi\varepsilon_0 R^2$

Sol. 7 Correct option is (A).

According to Gauss's law, the total electric flux coming out of the concentric spherical surface is equal to the charge enclosed by the surface, i.e.

$$Q = \oint D \cdot ds$$

Since, the electric potential is defined as

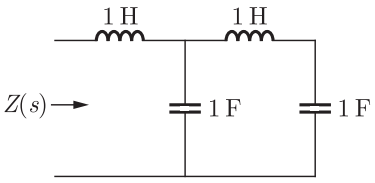
$$v = \frac{Q}{4\pi\varepsilon_0 r}$$

So, $$Q = v \times 4\pi\varepsilon_0 r$$

$$= 4\pi\varepsilon_0 r \quad \text{(since, } v = 1 \text{ volt)}$$

Hence, $$\oint D \cdot ds = 4\pi\varepsilon_0 r$$

Q. 8 The driving point impedance $Z(s)$ for the circuit shown below is

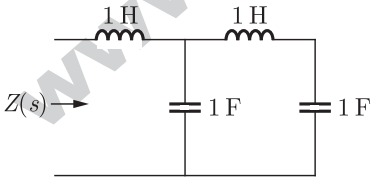


(A) $\frac{s^4 + 3s^2 + 1}{s^3 + 2s}$ (B) $\frac{s^4 + 2s^2 + 4}{s^2 + 2}$

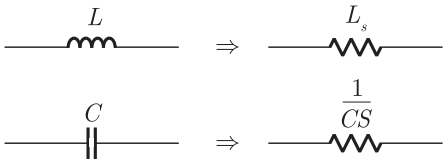
(C) $\frac{s^2 + 1}{s^4 + s^2 + 1}$ (D) $\frac{s^3 + 1}{s^4 + s^2 + 1}$

Sol. 8 Correct option is (A).

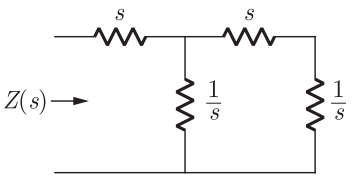
We have the impedance circuit,



The capacitor and inductor can be replaced with its equivalent reactance (in frequency domain) as shown below.



So, we have the equivalent circuit as



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Solving the above circuit, we get the equivalent driving point impedance as

$$Z(s) = s + \frac{1}{s} || \left(s + \frac{1}{s}\right)$$

$$= s + \frac{1}{s} || \left(\frac{s^2+1}{s}\right)$$

$$= s + \frac{\frac{1}{s} \times \frac{s^2+1}{s}}{\frac{1}{s} + \frac{s^2+1}{s}}$$

$$= s + \frac{s^2+1}{s^3+2s}$$

or $$Z(s) = \frac{s^4+3s^2+1}{s^3+2s}$$

Q. 9 A signal is represented by

$$x(t) = \begin{cases} 1 & |t| < 1 \\ 0 & |t| > 1 \end{cases}$$

The Fourier transform of the convolved signal $y(t) = x(2t) * x(t/2)$ is

(A) $\frac{4}{\omega^2}\sin\left(\frac{\omega}{2}\right)\sin(2\omega)$ (B) $\frac{4}{\omega^2}\sin\left(\frac{\omega}{2}\right)$

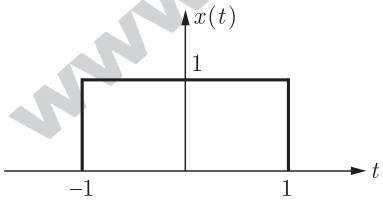
(C) $\frac{4}{\omega^2}\sin(2\omega)$ (D) $\frac{4}{\omega^2}\sin^2\omega$

Sol. 9 Correct option is (A).

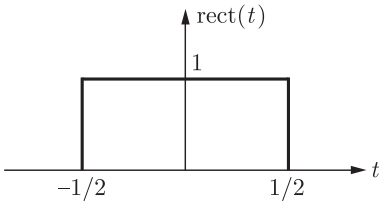
Given the signal,

$$x(t) = \begin{cases} 1, & |t| < 1 \\ 0, & |t| > 1 \end{cases}$$

The waveform for the given signal is drawn as



Since, the waveform of rectangular function $\text{rect}(t)$ is



So, comparing the two waveforms, we get

$$x(t) = \text{rect}\left(\frac{t}{2}\right)$$

Now, the Fourier transform pair for rectangular function is

$$\text{rect}\left(\frac{t}{\tau}\right) \longleftrightarrow \tau \sin C\left(\frac{\omega\tau}{2\pi}\right)$$

so, $$\text{rect}\left(\frac{t}{2}\right) \longleftrightarrow 2\sin C\left(\frac{\omega}{\pi}\right) = \frac{2\sin\omega}{\omega}$$

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Similarly, $$\text{rect}\left(\frac{t}{4}\right) \longleftrightarrow 4\sin C\left(\frac{2\omega}{\pi}\right) = \frac{4\sin(2\omega)}{2\omega} = \frac{2\sin(2\omega)}{\omega}$$

and $$\text{rect}(t) \longleftrightarrow \sin C\left(\frac{\omega}{2\pi}\right) = \frac{\sin(\omega/2)}{\omega/2}$$

Therefore, we have the fourier transforms

$$\begin{aligned}\mathcal{F}\{x(2t)\} &= \mathcal{F}\{\text{rect}(t)\} \\ &= \frac{\sin(\omega/2)}{\omega/2}\end{aligned}$$

and $$\mathcal{F}\{x(t/2)\} = \mathcal{F}\{\text{rect}(t/4)\} = \frac{2\sin(2\omega)}{\omega}$$

Thus, we obtain the fourier transform of signal $y(t)$ as

$$\begin{aligned}\mathcal{F}\{y(t)\} &= \mathcal{F}\{x(2t) * x(t/2)\} \\ &= \mathcal{F}\{x(2t)\}.\mathcal{F}\{x(t/2)\} \\ &= \frac{\sin(\omega/2)}{\omega/2}\frac{2\sin(2\omega)}{\omega} \\ &= \frac{4}{\omega^2}\sin\left(\frac{\omega}{2}\right)\sin(2\omega)\end{aligned}$$

Q. 10 For the signal $f(t) = 3\sin 8\pi t + 6\sin 12\pi t + \sin 14\pi t$, the minimum sampling frequency (in Hz) satisfying the Nyquist criterion is _____.

Sol. 10 Correct answer is 14 Hz.

Given the signal,

$$f(t) = 3\sin 8\pi t + 6\sin 12\pi t + \sin 14\pi t$$

According to Nyquist criterion the sampling frequency is

$$f_s > 2f_{\max}$$

where $f_{\max}$ is the maximum frequency of the message signal. For the given signal, we have maximum frequency as

$$\omega_{\max} = 14\pi$$

or $$2\pi f_{\max} = 14\pi$$

or $$f_{\max} = 7$$

Thus, the sampling frequency is

$$f_s > 2 \times 7$$

or $$f_s > 14$$

i.e. minimum sampling frequency is 14 Hz.

Q. 11 In a synchronous machine, hunting is predominantly damped by

(A) mechanical losses in the rotor (B) iron losses in the rotor

(C) copper losses in the stator (D) copper losses in the rotor

Sol. 11 Correct option is (D).

After sudden change of the load in three phase synchronous machine, the rotor has to search or hunt for its new equilibrium position. It causes the hunting, which can be damped by rotor copper losses.

Q. 12 A single phase induction motor is provided with capacitor and centrifugal switch in series with auxiliary winding. The switch is expected to operate at a speed of 0.7 Ns, but due to malfunctioning the switch fails to operate. The torque-speed characteristic of the motor is represented by

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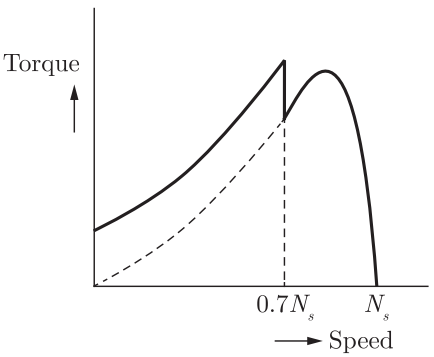
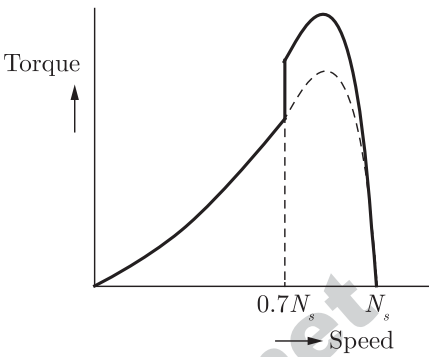
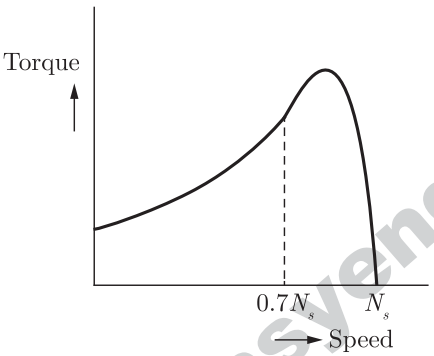
(A)



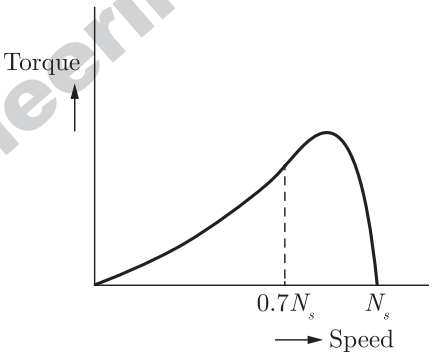
(B)



(C)

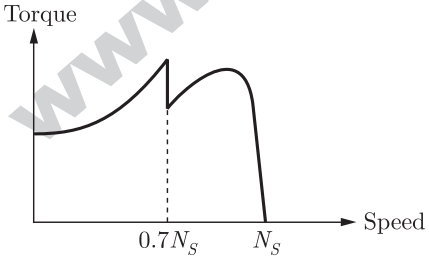


(D)

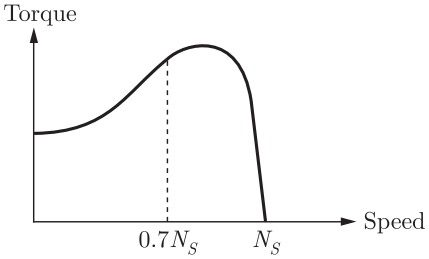


Sol. 12 Correct answer is (C).

If the switch operates correctly, then the torque-speed characteristic is



But, the switch does not operate due to malfunctioning. So, there will be no discontinuity in the characteristic curve. Thus, we have the modified characteristic curve of the motor as



Q. 13 The no-load speed of a 230 V separately excited dc motor is 1400 rpm. The armature resistance drop and the brush drop are neglected. The field current is kept constant at rated value. The torque of the motor in Nm for an armature current of 8 A is _ _ _ _ _ _ _ _.

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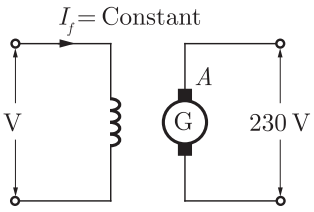
Sol. 13 Correct answer is 12.55 N-m.

A dc motor circuit is shown below.



Given

No load speed, $N = 1400$ rpm

Armature current, $I_a = 8$ A

Excitation voltage, $V = 230$ V

So, we obtain the torque of the motor as

$$\tau = \frac{V I_a}{\omega} = \frac{V I_a}{\frac{2\pi}{60} \times N}$$

$$= \frac{230 \times 8}{\frac{2\pi}{60} \times 1400}$$

$$= 9.55 \times \frac{230 \times 8}{1400}$$

$$= 12.55 \text{ N-m}$$

Q. 14 In a long transmission line with r, l, g and c are the resistance, inductance, shunt conductance and capacitance per unit length, respectively, the condition for distortionless transmission is

(A) $rc = lg$ (B) $r = \sqrt{l/c}$

(C) $rg = lc$ (D) $g = \sqrt{c/l}$

Sol. 14 Correct option is (A).

For a transmission line to be distortionless, the required condition is

$$\frac{R}{L} = \frac{G}{C}$$

where G = shunt conductance (in siemens/meter)

C = capacitance (in Farad/meter)

R = Resistance (in ohm/meter)

L = inductance (in henries per meter)

So, for the given parameters of long transmission line, the required condition for distortionless transmission becomes

$$\frac{r}{l} = \frac{g}{c}$$

or $$rc = lg$$

Q. 15 For a fully transposed transmission line

(A) positive, negative and zero sequence impedances are equal

(B) positive and negative sequence impedances are equal

(C) zero and positive sequence impedances are equal

(D) negative and zero sequence impedances are equal

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Sol. 15 Correct option is (B).
A fully transposed transmission line is completely symmetrically and therefore the phase impedance offered by it is independent of phase sequence of a balanced set of current. In other word impedance offered by it to positive and negative sequence currents are equal.

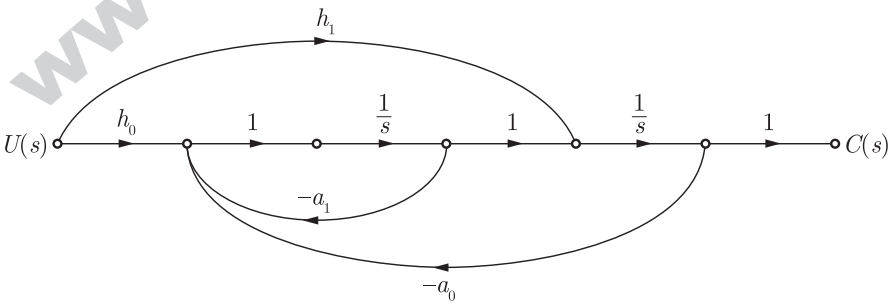
Q. 16 A 183 bus power system has 150 PQ buses and 32 PV buses. In the general case, to obtain the load flow solution using Newton-Raphson method in polar coordinates, the minimum number of simultaneous equations to be solved is _____.

Sol. 16 Correct answer is 332.
Given, number of PQ buses $= 150$
number of PV buses $= 32$
For PQ buses, 2 equations are formed (one for P and other for Q)
For PV buses only 1 equation is formed (for Q only)
Thus, the minimum number of simultaneous equations, required to obtain the load, is

Total number of equations = Number of equation for PQ buses + Number of equation for PV buses.

$$= 2 \times (\text{number of PQ buses}) + 1 \times (\text{number of PV buses})$$
$$= 2 \times (150) + 1 \times (32)$$
$$= 332$$

Q. 17 The signal flow graph of a system is shown below. $U(s)$ is the input and $C(s)$ is the output.



Assuming, $h_1 = b_1$ and $h_0 = b_0 - b_1 a_1$, the input-output transfer function, $G(s) = \dfrac{C(s)}{U(s)}$ of the system is given by

(A) $G(s) = \dfrac{b_0 s + b_1}{s^2 + a_0 s + a_1}$ (B) $G(s) = \dfrac{a_1 s + a_0}{s^2 + b_1 s + b_0}$

(C) $G(s) = \dfrac{b_1 s + b_0}{s^2 + a_1 s + a_0}$ (D) $G(s) = \dfrac{a_0 s + a_1}{s^2 + b_0 s + b_1}$

Sol. 17 Correct option is (C).
We have the signal flow graph of the system as

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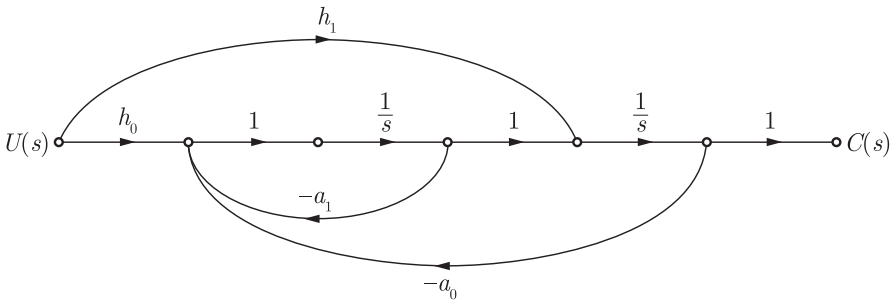

Now, we have to obtain the transfer function,

$$G(s) = \frac{C(s)}{U(s)}$$

From the SFG, we have two forward paths given as

$$p_1 = h_0 1 \frac{1}{s} 1 \frac{1}{s} 1 = \frac{h_0}{s^2}$$

$$p_2 = h_1 \frac{1}{s} 1 = \frac{h_1}{s}$$

The graph determinant is given by

$$\Delta = 1 - (\text{sum of all loop gains}) + (\text{sum of all gain products of 2 non-touching loops}) - (\text{sum of all gain products of 3 non-touching loops}) + \ldots$$

So,
$$\Delta = 1 - \left(\frac{-a_1}{s} + \frac{-a_0}{s^2}\right)$$

$$= 1 + \frac{a_1}{s} + \frac{a_0}{s^2}$$

Also, we have the determinants for the forward paths p_1 and p_2 as

$$\Delta_1 = 1$$

$$\Delta_2 = 1 - \left(\frac{-a_1}{s}\right) = 1 + \frac{a_1}{s}$$

Thus, using Mason's gain formula, we obtain the transfer function as

$$\text{T.F.} = \frac{\sum p_k \Delta_k}{\Delta} = \frac{p_1\Delta_1 + p_2\Delta_2}{\Delta}$$

$$= \frac{\frac{h_0}{s^2}(1) + \frac{h_1}{s}\left(1 + \frac{a_1}{s}\right)}{1 + \frac{a_1}{s} + \frac{a_0}{s^2}}$$

$$= \frac{h_0 + h_1(s + a_1)}{s^2 + a_1 s + a_0}$$

Since, we have

$$h_1 = b_1$$

and
$$h_0 = b_0 - b_1 a_1$$

Substituting it in equation (i), we get

$$\text{T.F.} = \frac{b_0 + b_1 s}{s^2 + a_1 s + a_0}$$

or
$$G(s) = \frac{C(s)}{V(s)} = \frac{b_0 + b_1 s}{s^2 + a_1 s + a_0}$$

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Q. 18 A single-input single output feedback system has forward transfer function $G(s)$ and feedback transfer function $H(s)$. It is given that $|G(s)H(s)| < 1$. Which of the following is true about the stability of the system ?

(A) The system is always stable

(B) The system is stable if all zeros of $G(s)H(s)$ are in left half of the s-plane

(C) The system is stable if all poles of $G(s)H(s)$ are in left half of the s-plane

(D) It is not possible to say whether or not the system is stable from the information given

Sol. 18 Correct option is (A).

For the given system, we have

$$|G(s)H(s)| < 1$$

So, we may easily conclude that the Nyquist-plot intersect the negative real axis between 0 and -1 point, i.e. the Nyquist plot does not enclose the point $(-1, 0)$ or in other words number of encirclements is zero.

$$N = 0 \quad \text{...(i)}$$

From Nyquist criterion, we have the relation

$$N = P - Z \quad \text{...(ii)}$$

where P is the number of open loop poles in right-half of s-plane and Z is the number of closed loop poles (roots of characteristic equation) in right-half of s-plane. Since, for a stable closed loop system, we must have

$$Z = 0 \quad \text{...(iii)}$$

Thus, from equations (i), (ii), and (iii), we get

$$P = 0$$

i.e. no poles of open loop system lies in right-half of s-plane, or in other words, all the poles lies in left-half of s-plane.

Hence, the given system is stable if all poles of $G(s)H(s)$ are in left half of the s-plane.

Q. 19 An LPF wattmeter of power factor 0.2 is having three voltage settings 300 V, 150 V and 75 V, and two current settings 5 A and 10 A. The full scale reading is 150. If the wattmeter is used with 150 V voltage setting and 10 A current setting, the multiplying factor of the wattmeter is _ _ _ _ _ _ _.

Sol. 19 Correct answer is 2.

In low power factor (LPF) wattmeter, the multiplying factor is given by

$$\text{M.F.} = \frac{\text{power setting}}{\text{power for maximum difflection}}$$

$$= \frac{(\text{voltage range used}) \times (\text{current range used}) \times (\text{power factor})}{\text{Full scale reading}}$$

From the given data, we have

$$\text{Full scale reading} = 150$$

$$\text{Voltage range used} = 150 \text{ V}$$

$$\text{Current range used} = 10 \text{ A}$$

$$\text{Power factor} = 0.2$$

Substituting these values in above expression, we get

$$\text{M.F.} = \frac{150 \times 10 \times 0.2}{150} = 2$$

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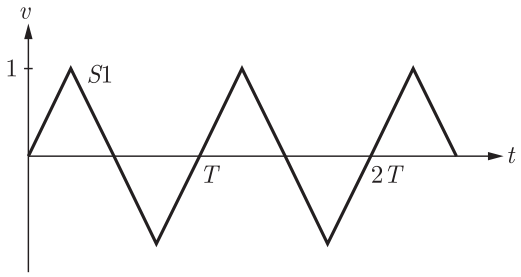
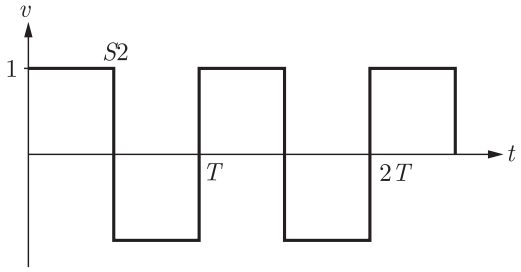
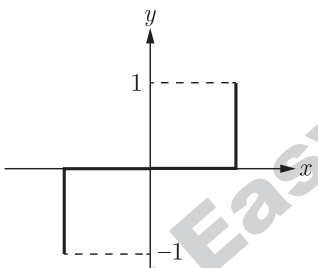
Q. 20 The two signals $S1$ and $S2$, shown in figure, are applied to Y and X deflection plates of an oscilloscope.



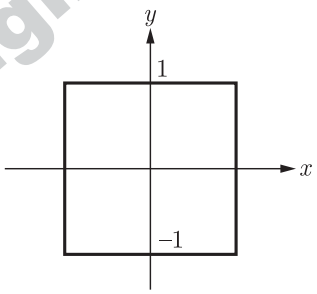


The waveform displayed on the screen is

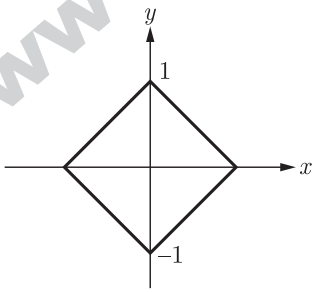
(A)



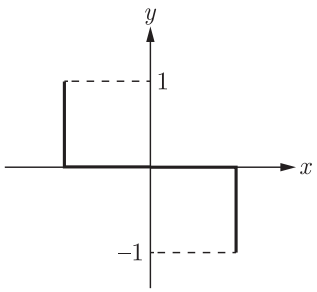
(B)



(C)



(D)



Sol. 20 Correct option is (A).

We consider the two signals S_1 and S_2 applied to Y and X deflection plates for the period T as

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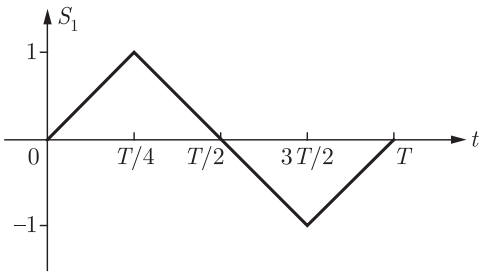
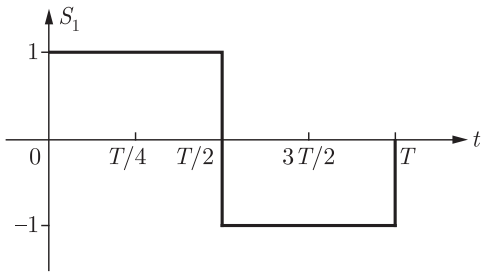
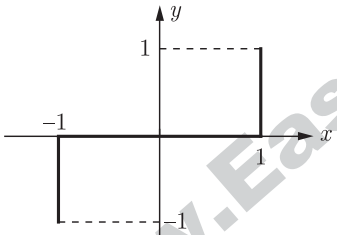


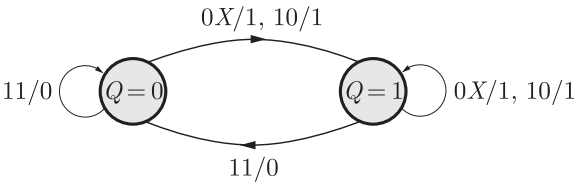


observing the waveforms, we condude that
For $0 < t < T/2$, $0 < S_1 < 1$ and $S_2 = 1$
At $t = \frac{T}{2}$, $S_1 = S_2 = 0$
For $\frac{T}{2} < t < T$, $0 > S_1 > -1$ and $S_2 = -1$

Since, S_1 is applied to Y-deflection plate and S_2 is applied to X-deflection plate. So, we have
For $0 < t < T/2$; $0 < y < 1, x = 1$
At $t = T/2$; $x = y = 0$
For $T/2 < t < T$; $-1 < y < 0$, $x = -1$
Thus, the waveform displayed on the CRT screen is

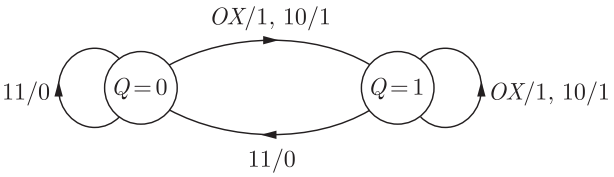


Q. 21 A state diagram of a logic gate which exhibits a delay in the output is shown in the figure, where X is the don't care condition, and Q is the output representing the state.



The logic gate represented by the state diagram is
(A) XOR (B) OR
(C) AND (D) NAND

Sol. 21 Correct option is (D).
We have the state diagram of a logic gate,



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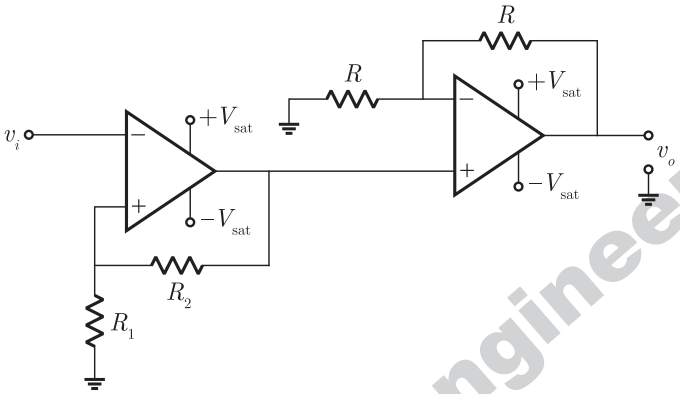
For the state diagram, we form the truth table (irrespective of the current state) as

A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

Thus, from the truth table, it is clear that the logic gate is NAND gate.

Q. 22 An operational amplifier circuit is shown in the figure.



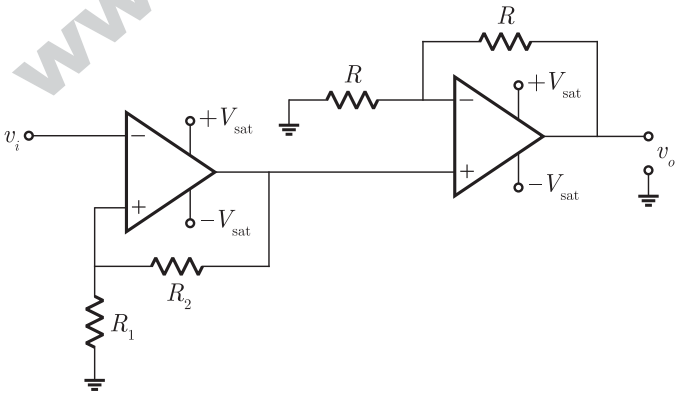
The output of the circuit for a given input v_i is

(A) $-\left(\frac{R_2}{R_1}\right)v_i$ (B) $-\left(1+\frac{R_2}{R_1}\right)v_i$

(C) $\left(1+\frac{R_2}{R_1}\right)v_i$ (D) $+V_{sat}$ or $-V_{sat}$

Sol. 22 Correct option is (D).

We have the op-amp circuit as



For an operation amplifier, we know that

1. If $v_i > V_{sat}$; then output voltage will be V_{sat}
2. If $v_i < -V_{sat}$; then the output voltage will be $-V_{sat}$
3. If $-V_{sat} < v_i < V_{sat}$; then the output voltage varies according to the applied input.

For the given op-amp circuit, we assume that

$$-V_{sat} < v_i < V_{sat}$$

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So, we obtain the output for the corresponding input v_i. Applying KCL at non-inverting terminal of first op-amp, we have

$$\frac{v_i - 0}{R_1} + \frac{v_i - x}{R_2} = 0$$

or $$v_i\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{x}{R_2}$$

or $$x = \left(\frac{R_1 + R_2}{R_1}\right)v_i \quad \text{...(i)}$$

where x is the voltage at non-inverting terminal of second op-amp. Again, applying KCL at non-inverting terminal of second op-amp, we get

$$\frac{x - 0}{R} + \frac{x - v_0}{R} = 0$$

or $$v_0 = 2x$$

or $$v_0 = \frac{2v_i}{R_1}(R_1 + R_2) \quad \text{[substituting equation (i)]}$$

$$= 2v_i\left(1 + \frac{R_2}{R_1}\right)$$

There is no single option so our assumption is wrong and $v_i > +V_{sat}$ and $v_i < -V_{sat}$. So, the output voltage is $+V_{sat}$ and $-V_{sat}$.

Q. 23 In 8085A microprocessor, the operation performed by the instruction LHLD 2100_H is

(A) $(H) \leftarrow 21_H$, $(L) \leftarrow 00_H$

(B) $(H) \leftarrow M(2100)_H$, $(L) \leftarrow M(2101_H)$

(C) $(H) \leftarrow M(2101_H)$, $(L) \leftarrow M(2100_H)$

(D) $(H) \leftarrow 00_H$, $(L) \leftarrow 21_H$

Sol. 23 Correct option is (C).

For the 8085A microprocessor, given instruction is

LHLD 2100_H

This operation loads registers register L and H with the content in memory at locations 2100_H and 2101_H respectively, i.e.

$$(H) \leftarrow M(2101)_H \text{ and } (L) \leftarrow M(2100)_H$$

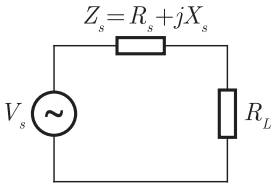
Q. 24 A non-ideal voltage source V_s has an internal impedance of Z_s. If a purely resistive load is to be chosen that maximizes the power transferred to the load, its value must be

(A) 0 (B) real part of Z_s

(C) magnitude of Z_s (D) complex conjugate of Z_s

Sol. 24 Correct option is (C).

Consider the circuit shown below with non-ideal voltage source V_s, an internal impedance $Z_s = R_s + jX_s$, and purely resistive load R_L.



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Current through the circuit is given by

$$I = \frac{V_s}{R_s + R_L + jX_s}$$

or
$$I = \frac{V_s}{\sqrt{(R_s + R_L) + (X_s)^2}}$$

Therefore, the power transferred to load is

$$P = I^2 R_L$$

$$= \frac{V_s^2 R_L}{((R_s + R_L)^2 + X_s^2)}$$

For maximum power, we have

$$\frac{dP}{dR_L} = 0$$

or
$$\frac{[(R_s + R_L)^2 + X_s^2]1 - 2R_L(R_s + R_L)}{((R_s + R_L)^2 + X_s^2)^2} = 0$$

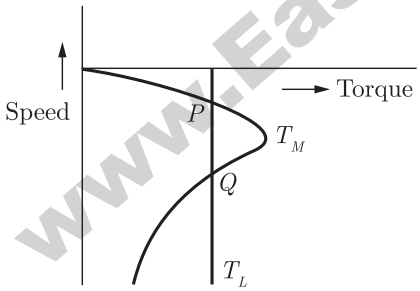
or
$$R_s^2 + R_L^2 + 2R_sR_L + X_s^2 - 2R_sR_L - 2R_L^2 = 0$$

or
$$R_s^2 + X_s^2 = R_L^2$$

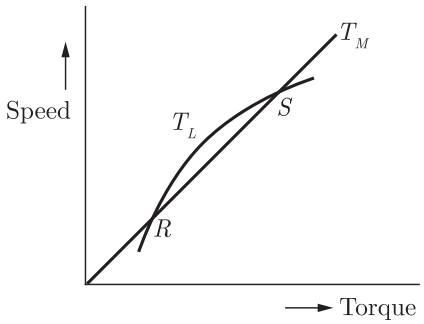
or
$$R_L = \sqrt{R_s^2 + X_s^2}$$

i.e. to maximise the power transferred to pure resistive load (R_L), its value must be equal to the magnitude of Z_s of internal circuit.

Q. 25 The torque speed characteristics of motor (T_M) and load (T_L) for two cases are shown in the figures (a) and (b). The load torque is equal to motor torque at points P, Q, R and S.



(a)



(b)

The stable operating points are

(A) P and R (B) P and S

(C) Q and R (D) Q and S

Sol. 25 Correct option is (B).

Since, increase in torque accelerates the motor, so the slope of torque speed characteristic should be negative to restore the speed to original value, which in turn makes the system stable.

Thus, for stable operating point, the slope of torque-speed characteristic should be negative.

Hence, the points P and S are stable operating points.

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Q. 26 - Q. 55 Carry two marks each.

Q. 26 Integration of the complex function $f(z)=\frac{z^2}{z^2-1}$, in the counterclockwise direction, around $|z-1|=1$, is

(A) $-\pi i$ (B) 0

(C) πi (D) $2\pi i$

Sol. 26 Correct option is (C).

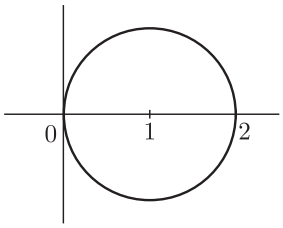
Given the complex function,

$$f(z)=\frac{z^2}{z^2-1}$$

and the contour, along which integration to be performed, is

$$C: \quad |z-1|=1$$

Here, $|z-1|=1$ is a circle with radius 1 and centre at point (1,0). So, we sketch the contour C as



Now, we have the complex function

$$f(z)=\frac{z^2}{z^2-1}$$

So, the poles and zeros of the function are

$$\text{poles} = 1, -1$$
$$\text{zeros} = 0, 0$$

Therefore, only pole ($z=1$) lies within the curve C. So, the residue at $z=1$ pole is

$$\text{Residue} = \lim_{z\to 1}\frac{z^2}{(z+1)}$$
$$= \lim_{z\to 1}\frac{z^2}{z+1}=\frac{1}{1+1}=\frac{1}{2}$$

Thus, the integral of complex function along the contour is obtained as

$$\int_C f(z)dz = 2\pi i \text{ (sum of residues)}$$
$$= 2\pi i\left(\frac{1}{2}\right)$$
$$= \pi i$$

Q. 27 The mean thickness and variance of silicon steel laminations are 0.2 mm and 0.02 respectively. The varnish insulation is applied on both the sides of the laminations. The mean thickness of one side insulation and its variance are 0.1 mm and 0.01 respectively. If the transformer core is made using 100 such varnish coated laminations, the mean thickness and variance of the core respectively are

(A) 30 mm and 0.22 (B) 30 mm and 2.44

(C) 40 mm and 2.44 (D) 40 mm and 0.24

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Sol. 27 Correct option is (D).

Q. 28 The function $f(x) = e^x - 1$ is to be solved using Newton-Raphson method. If the initial value of x_0 is taken as 1.0, then the absolute error observed at 2^{nd} iteration is _ _ _ _ _.

Sol. 28 Correct answer is 0.06005.

We have the function,

$$f(x) = e^x - 1$$

So, its first derivative is obtained as

$$f'(x) = e^x$$

By Newton-Raphson method, we have

$$x_{i+1} = x_i - \frac{f(x_i)}{f'(x_i)}$$

Since, we have the initial value,

$$x_0 = 1$$

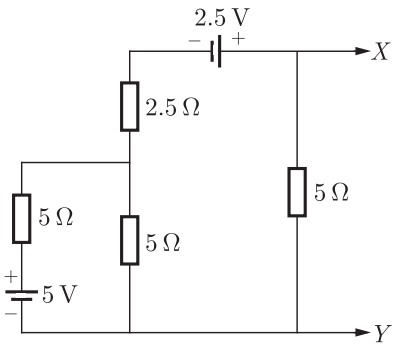
So, we obtain the 1st iteration as

$$\begin{aligned} x_1 &= x_0 - \frac{f(x_0)}{f'(x_0)} \\ &= x_0 - \frac{e^{x_0} - 1}{e^{x_0}} \\ &= 1 - \frac{e^1 - 1}{e^1} = e^{-1} = .3678 \end{aligned}$$

Therefore, the 2nd iteration is

$$\begin{aligned} x_2 &= x_1 - \frac{f(x_1)}{f'(x_1)} \\ &= x_1 - \frac{e^{x_1} - 1}{e^{x_1}} \\ &= x_1 - 1 + e^{-x_1} \\ &= 0.3678 - 1 + e^{-0.3678} \\ &= .06005 \end{aligned}$$

Q. 29 The Norton's equivalent source in amperes as seen into terminals X and Y is _ _ _ _.



Sol. 29 Correct answer is 2.

To obtain the Norton equivalent along X-Y terminal, we redraw the given circuit as

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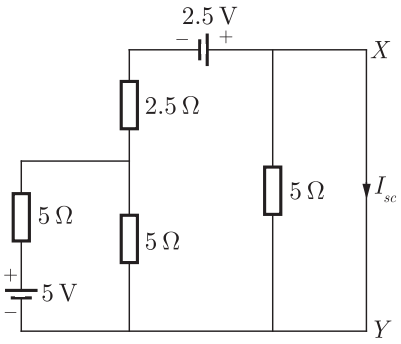
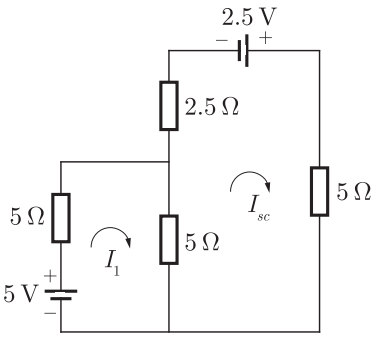


In the network, 5 Ω resistor is short-circuit. So, the equivalent circuit is



Now, writing the KVL equation in two loops, we have

$$5 - 5I_1 - 5(I_1 - I_{sc}) = 0 \quad \text{...(i)}$$

$$-5(I_{sc} - I_1) - 2.5I_{sc} + 2.5 = 0 \quad \text{...(ii)}$$

Solving equation (i),

$$10I_1 - 5I_{sc} = 5$$

$$2I_1 = I_{sc} + 1 \quad \text{...(iii)}$$

Solving equation (ii),

$$7.5I_{sc} - 5I_1 = 2.5$$

or $$3I_{sc} - 2I_1 = 1$$

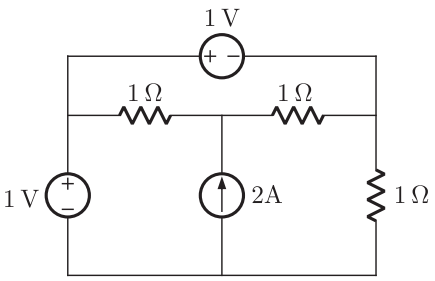
or $$3I_{sc} - I_{sc} - 1 = 1 \quad \text{[using equation (iii)]}$$

or $$2I_{sc} = 2$$

Thus, $$I_{sc} = 1\text{ A}$$

i.e. the Norton equivalent source as seen into terminals X and Y is 1 A.

Q. 30 The power delivered by the current source, in the figure, is _ _ _ _.



Sol. 30 Correct answer is 3 W.

To obtain the required unknown, we redraw the given circuit as

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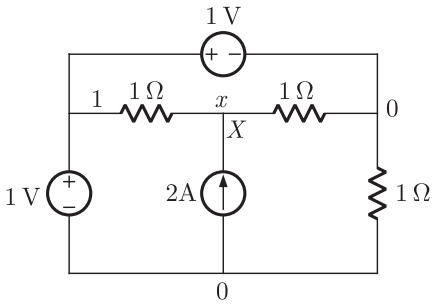


Applying KCL at node V_x, we have

$$\frac{V_x - 1}{1} + \frac{V_x}{1} = 2$$

or $$2V_x - 1 = 2$$

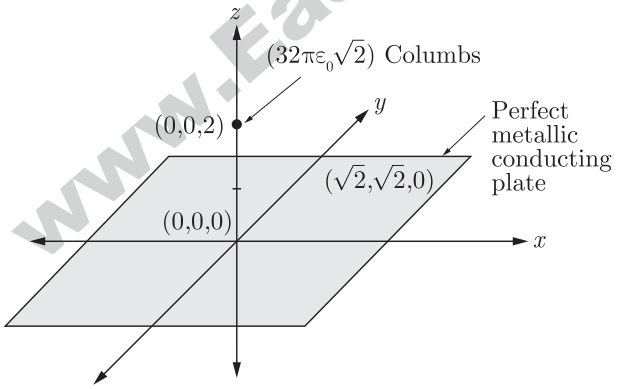
or $$V_x = \frac{3}{2}$$

Therefore, the power delivered by current source is obtained as

= Voltage across current source × current through current source

$$= \frac{3}{2} \times 2 = 3 \text{ W}$$

Q. 31 A perfectly conducting metal plate is placed in x-y plane in a right handed coordinate system. A charge of $+32\pi\varepsilon_0\sqrt{2}$ coulombs is placed at coordinate $(0,0,2)$. ε_0 is the permittivity of free space. Assume i, j, k to be unit vectors along x, y and z axes respectively. At the coordinate $(\sqrt{2},\sqrt{2},0)$, the electric field vector E (Newtons/Coulomb) will be



(A) $2\sqrt{2}\,k$ (B) $-2k$

(C) $2k$ (D) $-2\sqrt{2}\,k$

Sol. 31 Correct option is (D).

We have the given system of a charge and a perfectly conducting metal plate as shown below.

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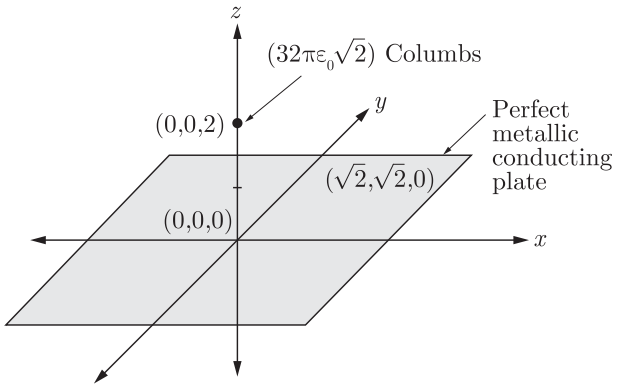
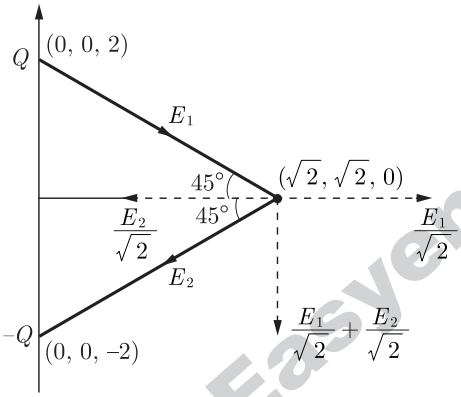


Due to presence of conducting plane, we can assume an image charge for the system as shown below



So, we can observe from the figure that electric field vector along x-y plane is cancelled, i.e. zero. Therefore, the electric field vector acts along negative z-direction and given as

$$\vec{E} = \left(\frac{E_1}{\sqrt{2}} + \frac{E_2}{\sqrt{2}}\right)(-\hat{k}) \qquad ...(i)$$

where E_1 and E_2 are the field intensity due to the charge Q and $-Q$ at point $(\sqrt{2}, \sqrt{2}, 0)$. So, we obtain

$$E_1 = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{32\pi\varepsilon_0\sqrt{2}}{(\sqrt{(\sqrt{2})^2 + (\sqrt{2})^2 + (2)^2})^2}$$
$$= \sqrt{2}$$

Similarly, we get, $E_2 = \sqrt{2}$

Substituting these values in equation (i), we obtain

$$\vec{E} = \left(\frac{\sqrt{2}}{\sqrt{2}} + \frac{\sqrt{2}}{\sqrt{2}}\right)(-\hat{k})$$
$$= -2\hat{k}$$

Q. 32 A series RLC circuit is observed at two frequencies. At $\omega_1 = 1\,\text{krad/s}$, we note that source voltage $V_1 = 100\angle 0^\circ\,\text{V}$ results in a current $I_1 = 0.03\angle 31^\circ\,\text{A}$. At $\omega_2 = 2\,\text{krad/s}$, the source voltage $V_2 = 100\angle 0^\circ\,\text{V}$ results in a current $I_2 = 2\angle 0^\circ\,\text{A}$. The closest values for R, L, C out of the following options are

(A) $R = 50\,\Omega$; $L = 25\,\text{mH}$; $C = 10\,\mu\text{F}$; (B) $R = 50\,\Omega$; $L = 10\,\text{mH}$; $C = 25\,\mu\text{F}$;

(C) $R = 50\,\Omega$; $L = 50\,\text{mH}$; $C = 5\,\mu\text{F}$; (D) $R = 50\,\Omega$; $L = 5\,\text{mH}$; $C = 50\,\mu\text{F}$;

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Sol. 32 Correct option is (B).

Given the current and voltage at different frequencies as

At $\omega_1 = 1\,\text{krad/s}$, $V_1 = 100\angle 0$ $I_1 = 0.03\angle 31^\circ$

At $\omega_2 = 2\,\text{krad/s}$, $V_2 = 100\angle 0$ $I_2 = 2\angle 0^\circ$

From the given data, it is clear that voltage and current are in phase at $\omega_2 = 2$. So, it satisfies the resonance condition. Therefore, we have

$$R = \frac{V}{I} = \frac{100}{2} = 50\,\Omega$$

Also, for the resonance circuit, we have

$$\omega L = \frac{1}{\omega C}$$

or $$10^3 \times 2 \times L = \frac{1}{2 \times C \times 10^3}$$

or $$4 \times 10^6 L = \frac{1}{C} \quad \text{...(i)}$$

Again, at $\omega = 1$ krad/s, we have

$$\cos 31^\circ = \frac{R}{Z}$$

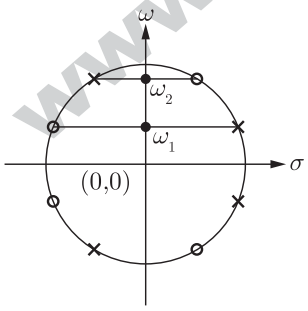
or $$\cos 31^\circ = \frac{R}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

or $$\cos 31^\circ = \frac{50}{\sqrt{2500 + \left(10^3 L - \frac{1}{10^3 C}\right)}} \quad \text{...(ii)}$$

Solving equations (i) and (ii), we get

$$L = 10\,\text{mH} \text{ and } C \approx 25\,\mu\text{F}$$

Q. 33 A continuous-time LTI system with system function $H(\omega)$ has the following pole-zero plot. For this system, which of the alternatives is TRUE ?



(A) $|H(0)| > |(\omega)|;\ |\omega| > 0$

(B) $|H(\omega)|$ has multiple maxima, at ω_1 and ω_2

(C) $|H(0)| < |H(\omega)|;\ |\omega| > 0$

(D) $|H(\omega)| =$ constant; $-\infty < \omega < \infty$

Sol. 33 Correct option is (D).

To obtain the system function, we redraw the given pole-zero plot as

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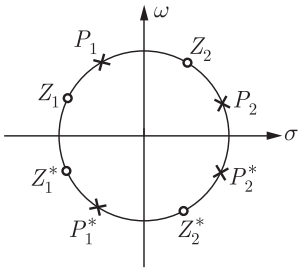

From the pole-zero plot, we obtain the transfer function as

$$H(\omega) = K\frac{(S-Z_1)(S-Z_1^*)(S-Z_2)(S-Z_2^*)}{(S-P_1)(S-P_1^*)(S-P_2)(S-P_2^*)}$$

So, $$|H(\omega)| = K\left|\frac{(S-Z_1)(S-Z_1^*)(S-Z_2)(S-Z_2^*)}{(S-P_1)(S-P_1^*)(S-P_2)(S-P_2^*)}\right| \quad ...(i)$$

Since, we can observe from the pole-zero plot that

$$|P_1| = |Z_2|$$

and $$|P_2| = |Z_1|$$

Thus, the numerator and denominator terms of equation are cancelled. Hence, we get

$$|H(\omega)| = K$$

Q. 34 A sinusoid $x(t)$ of unknown frequency is sampled by an impulse train of period 20 ms. The resulting sample train is next applied to an ideal lowpass filter with cutoff at 25 Hz. The filter output is seen to be a sinusoid of frequency 20 Hz. This means that $x(t)$

(A) 10 Hz (B) 60 Hz

(C) 30 Hz (D) 90 Hz

Sol. 34 Correct option is (C).

Given the period of sampling train, $T_S = 20\,\text{ms}$

So, the sampling frequency is $f_S = \frac{1}{20 \times 10^{-3}} = 50\,\text{Hz}$

Let the frequency of signal $x(t)$ be f_x

After sampling the signal, the sampled signal has the frequency

$$f_S - f_x = 50 - f_x$$

and $$f_S + f_x = 50 + f_x$$

Now, the sampled signal is applied to an ideal low-pass filter with cut off frequency,

$$f_c = 25\,\text{Hz}$$

Since, the output of the filter carried a single frequency component of 20 Hz. So, it is clear that only lower component $(f_s - f_x)$ passes through the filter, i.e.

$$f_S - f_x < 25$$

and
$$f_S - f_x = 20$$
$$50 - f_x = 20$$
$$f_x = 50 - 20 = 30\,\text{Hz}$$

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Q. 35 A differentiable non constant even function $x(t)$ has a derivative $y(t)$, and their respective Fourier Transforms are $X(\omega)$ and $Y(\omega)$. Which of the following statments is TRUE ?

(A) $X(\omega)$ and $Y(\omega)$ are both real (B) $X(\omega)$ is real and $Y(\omega)$ is imaginary

(C) $X(\omega)$ and $Y(\omega)$ are both imaginary (D) $X(\omega)$ is imaginary and $Y(\omega)$ is real

Sol. 35 Correct option is (B).

Given the relation,

$$y(t) = \frac{d}{dt}x(t)$$

From the properties of Fourier transform we know that

if $$y(t) = \frac{d}{dt}x(t)$$

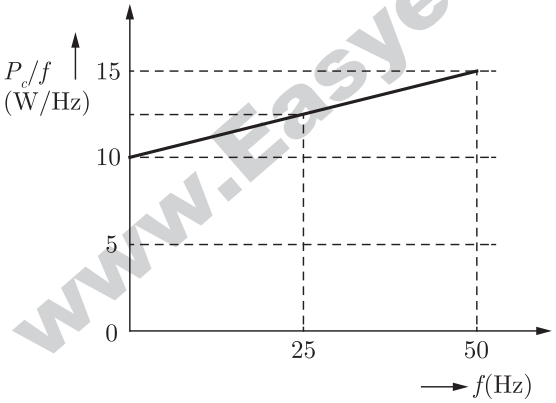
Then $$Y(\omega) = j\omega X(\omega) \quad \text{...(i)}$$

where $X(\omega)$ and $Y(\omega)$ are the Fourier transform of $x(t)$ and $y(t)$ respectively.

Now, we have the function $x(t)$, which is differentiable, non-constant, even function. So, its frequency response will be real, i.e. $X(\omega)$ is real

Hence, equation (i) gives the result that $Y(\omega)$ is imaginary.

Q. 36 An open circuit test is performed on 50 Hz transformer, using variable frequency source and keeping V/f ratio constant, to separate its eddy current and hysteresis losses. The variation of core loss/frequency as function of frequency is shown in the figure



The hysteresis and eddy current losses of the transformer at 25 Hz respectively are

(A) 250 W and 2.5 W (B) 250 W and 62.5 W

(C) 312.5 W and 62.5 W (D) 312.5 W and 250 W

Sol. 36 Correct option is (B).

Since, we know that

$$P_C = P_H f + P_e f^2 \quad \text{...(i)}$$

where P_C = total core losses of the transformer

f = frequency

P_H = Hysteresis losses constant

P_e = eddy current losses constant

Now, we have the plot of core loss/frequency versus frequency as

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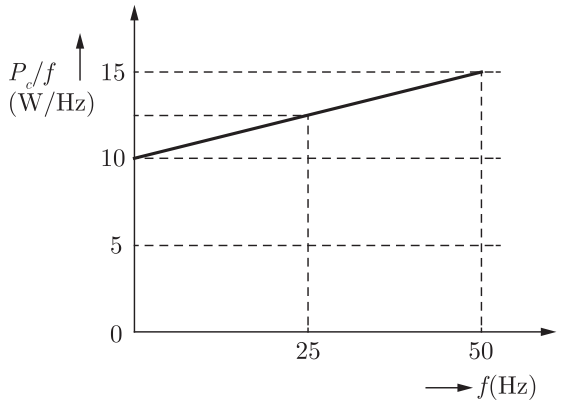

So, we rewrite equation (i) as

$$\frac{P_C}{f} = P_H + P_e f \qquad \text{...(ii)}$$

i.e. the plot between P_C/f and f is a straight line. From the graph, we have the values of P_H and P_e as

$$P_H = 10\ ; \quad P_e = \frac{1}{10}$$

From equation (i), we have the hysteresis and eddy current losses as

$$P_e = \underbrace{P_H f}_{\text{Hysteresis loss}} + \underbrace{P_e f^2}_{\text{Eddy current loss}}$$

Thus, we get

$$P_H f = 10 \times 25 = 250 \text{ W}$$

$$P_e f^2 = \frac{1}{10} \times (25)^2 = 62.5 \text{ W}$$

Q. 37 A non-salient pole synchronous generator having synchronous reactance of 0.8 pu is supplying 1 pu power to a unity power factor load at a terminal voltage of 1.1 pu. Neglecting the armature resistance, the angle of the voltage behind the synchronous reactance with respect to the angle of the terminal voltage in degrees is _____.

Sol. 37 Correct answer is 33.47°.

For the non-salient synchronous generator, we have

Synchronous reactance, $X_S = 0.8$ p.u.

Supplied power, $P = 1$ p.u.

Power, factor, $\cos\phi = 1$

Terminal voltage, $V_t = 1.1$ p.u.

Since, power factor is unity, so phase angle of armature current is also zero. So, we get

$$I_a = \frac{P}{V_t \cos\phi} = \frac{1}{(1.1)(1)} = \frac{1}{1.1}$$

or $$I_a = \frac{1}{1.1} < 0^\circ$$

Again, we define the armature current as

$$I_a = \frac{E_f \angle\delta - V_t \angle 0}{jX_S}$$

So, $$E_f \angle\delta = I_a(jX_S) + V_t < 0$$

$$= \frac{1}{1.1\angle 0}(j0.8) + 1.1\angle 0$$

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$$= \frac{1}{1.1\angle 0}0.8\angle 90^\circ + 1.1\angle 0$$
$$= 1.1\angle 0 + \frac{0.8}{1.1}\angle 90^\circ$$

or $$E_f \cos\delta + jE_f \sin\delta = 1.1 + j\frac{0.8}{1.1} \quad ...(i)$$

Now, we have the power equation

$$P = \frac{E_f V_t}{X_S}\sin\delta$$
$$1 = \frac{E_f(1.1)}{0.8}\sin\delta$$
$$E_f \sin\delta = \frac{0.8}{1.1} \quad ...(ii)$$

So, from equation (i), we get

$$E_f \cos\delta = 1.1 \quad ...(iii)$$

Dividing equation (ii) by equation (iii), we get

$$\frac{E_f \sin\delta}{E_f \cos\delta} = \frac{0.8}{1.1 \times 1.1}$$
$$\tan\delta = \frac{0.8}{1.21}$$
$$\delta = \tan^{-1}\left(\frac{0.8}{1.21}\right) = 33.47^\circ$$

Q. 38 A separately excited 300 V DC shunt motor under no load runs at 900 rpm drawing an armature current of 2 A. The armature resistance is 0.5 Ω and leakage inductance is 0.01 H. When loaded, the armature current is 15 A. Then, the speed in rpm is _ _ _ _ _.

Sol. 38 Correct answer is 880 rpm.

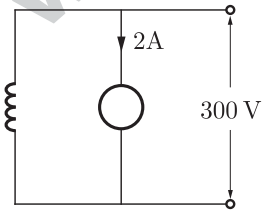
At no load, we have

Armature resistance, $r_a = 0.5\,\Omega$

Armature current, $I_a = 2\text{ A}$

Leakage inductance, $L = 0.01\text{ H}$

So, we draw the circuit as



Since, we have 300 V dc shunt motor, so we obtain

$$E_{\text{no load}(1)} = V - I_a R_a$$

or $$E_1 = 300 - 2(0.5)$$
$$= 300 - 1 = 299\text{ V}$$

Again, when the load is applied, we have

Armature resistance, $r_a = 0.5\,\Omega$

Armature current, $I_a = 15\text{ A}$

So, we draw the circuit as

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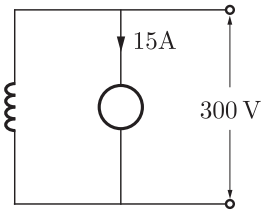


Therefore, we obtain

$$E_{\text{load(2)}} = V - I_a R_a$$

or $$E_2 = 300 - 15 \times 0.5$$

$$= 300 - 7.5 = 292.5$$

Since, we know that

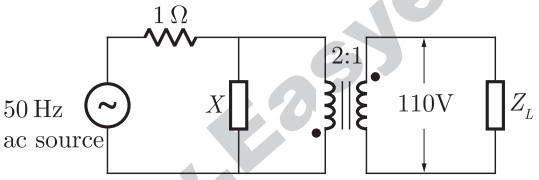
$$E \propto N$$

So, $$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$

or $$\frac{299}{292.5} = \frac{900}{N_2} \qquad (\text{given } N_1 = 900 \text{ rpm})$$

or $$N_2 = 880 \text{ rpm}$$

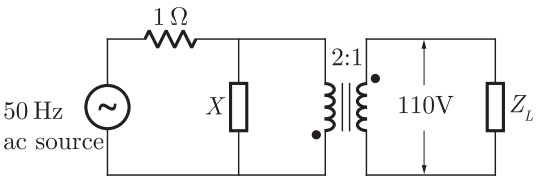
Q. 39 The load shown in the figure absorbs 4 kW at a power factor of 0.89 lagging.



Assuming the transformer to be ideal, the value of the reactance X to improve the input power factor to unity is _ _ _ _ _ _ _ _ _.

Sol. 39 Correct answer is 23.618 ohm.

We have the transformer circuit,



Given the power absorbed by load; $P_2 = 4\,\text{kW} = 4000\,\text{W}$.

and the power factor is $\cos\phi_2 = 0.89$ lagging

From the given circuit, voltage across load is $V_2 = 110$ V

So, the current through the load is

$$I_2 = \frac{P_2}{V_2 \cos\phi_2} \angle -\phi_2$$

$$= \frac{4000}{110 \times 0.89} \angle -\cos^{-1}0.89$$

$$= 40.858 \angle -27.13^\circ$$

This is the current through secondary winding of transformer. So, the current through primary winding is given by

$$\frac{I_1}{I_2} = \frac{N_2}{N_1}$$

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where N_1 = number of turns in primary winding

N_2 = Number of turns in secondary winding.

From the given circuit, we have

$$\frac{N_1}{N_2} = \frac{2}{1}$$

So,
$$\frac{I_1}{I_2} = \frac{1}{2}$$

Therefore,
$$I_1 = \frac{I_2}{2} = \frac{40.858\angle -27.13^\circ}{2}$$
$$= 20.43\angle 27.13^\circ$$

Since, it is required to improve the input power factor to unity. So, the input current should be red. Therefore, the imaginary part of I_1 should pass through reactance X. Thus, current through X is

$$I_X = I_m\{I_1\}$$
$$= 20.43\sin(27.13^\circ)$$
$$= 9.31$$

Hence, the reactance is

$$X = \frac{220}{I_X} = \frac{220}{9.31}$$
$$= 23.618\,\Omega$$

Q. 40 The parameters measured for a 220 V/110 V, 50 Hz, single phase transformer are :

Self inductance of primary winding = 45 mH

Self inductance of secondary winding = 30 mH

Mutual inductance between primary and secondary windings = 20 mH

Using the above parameters, the leakage (L_{l1}, L_{l2}) and magnetizing (L_m) inductance as referred to primary side in the equivalent circuit respectively, are

(A) 5 mH, 20 mH and 40 mH (B) 5 mH, 80 mH and 40 mH

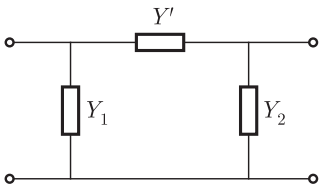
(C) 25 mH, 10 mH and 20 mH (D) 45 mH, 30 mH and 20 mH

Sol. 40 Correct option is (B).

For long transmission lines (over 200 km), parameters of a line are not lumped but distributed uniformally throughout its length. The $ABCD$ parameter of equivalent π circuit are given as

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \frac{1+YZ}{2} & Z\left(1+\frac{YZ}{6}\right) \\ Y\left(1+\frac{YZ}{6}\right) & 1+\frac{YZ}{2} \end{bmatrix} \quad ...(i)$$

The π-equivalent circuit



$ABCD$ parameter of above circuit

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1+Y_2Z & Z' \\ Y_1+Y_2+Y_1Y_2Z & 1+Y_1Z \end{bmatrix} \quad ...(ii)$$

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comparing equation (i) and (ii), we get

$$Z' = B = Z\left(1 + \frac{YZ}{6}\right)$$

where $Z = zl =$ total series impedance/phase

$Y = yl =$ total shunt admittance/phase

So, $Z = j0.5 \times 400 = j200\,\Omega$

$Y = j5 \times 10^{-6} \times 400 = j2 \times 10^{-3}\,\Omega$

So, Z'

$$= j200\left(1 + \frac{j2 \times 20^{-3} \times j200}{6}\right) = j200(-0.066)$$

$$= j200 \times 0.934 = j186.8\,\Omega$$

$$|Z'| = 186.8\,\Omega$$

Primary leakage reactance $L_{l1} = L_1 - 2M = 45 - 2(20)$

$= 5$ mH

Self inductance of secondary winding refers to primary side

$$L_2' = \left(\frac{N_1}{N_2}\right)^2 L_2 = \left(\frac{V_1}{V_2}\right)^2 L_2$$

$$= \left(\frac{220}{110}\right)^2 \times 30$$

So, $L_2' = 120$ mH

Leakage inductance of secondary referred to primary side

$$L_{l2} = L_2' - 2M$$

$$= 120 - 2(20) = 80 \text{ mH}$$

magnetizing inductance, $L_m = 2M = 2(20) = 40$ mm

Q. 41 For a 400 km long transmission line, the series impedance is $(0.0 + j0.5)\,\Omega/\text{km}$ and the shunt admittance is $(0.0 + j5.0)\,\mu\text{mho/km}$. The magnitude of the series impedance (in Ω) of the equivalent π circuit of the transmission line is _ _ _ _.

Sol. 41 Correct answer is 187

Q. 42 The complex power consumed by a constant-voltage load is given by $(P_1 + jQ_1)$, where, $1\,\text{kW} \le P_1 \le 1.5\,\text{kW}$ and $0.5\,\text{kVAR} \le Q_1 \le 1\,\text{kVAR}$

A compensating shunt capacitor is chosen such that $|Q| \le 0.25\,\text{kVAR}$, where Q is the net reactive power consumed by the capacitor load combination. The reactive power (in kVAR) supplied by the capacitor is _ _ _ _.

Sol. 42 Correct answer is 0.75kVAR.

Given the constant voltage load,

$$P_1 + jQ_1$$

where $1\,\text{kW} < P_1 < 1.5\,\text{kW}$

and $0.5\,\text{kVAR} \le Q_1 \le 1\,\text{kVAR}$

Now, the shunt capacitor is chosen such that reactive power across capacitor load is

$$|Q| \le 0.25\,\text{kVAR}$$

Since, we have $Q_1 = 1\,\text{kVAR}$, therefore, capacitor will supply

$$Q_C = .75\,\text{kVAR}$$

i.e. capacitor must supply $.75\,\text{kVAR}$.

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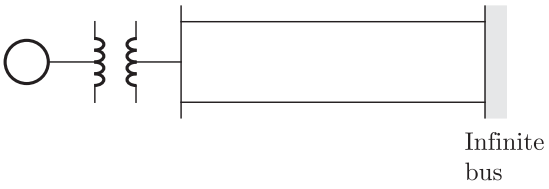
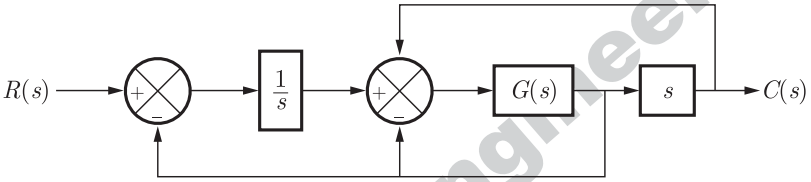
Q. 43 The figure shows the single line diagram of a single machine infinite bus system.



The inertia constant of the synchronous generator $H = 5$ MW-s/MVA. Frequency is 50 Hz. Mechanical power is 1 pu. The system is operating at the stable equilibrium point with rotor angle δ equal to 30°. A three phase short circuit fault occurs at a certain location on one of the circuits of the double circuit transmission line. During fault, electrical power in pu is $P_{\max}\sin\delta$. If the values of δ and $d\delta/dt$ at the instant of fault clearing are 45° and 3.762 radian/s respectively, then $P_{\max}$ (in pu) is _ _ _ _ _ _.

Sol. 43 Correct answer is 0.23 .

Q. 44 The block diagram of a system is shown in the figure



If the desired transfer function of the system is

$$\frac{C(s)}{R(s)} = \frac{s}{s^2+s+1}$$

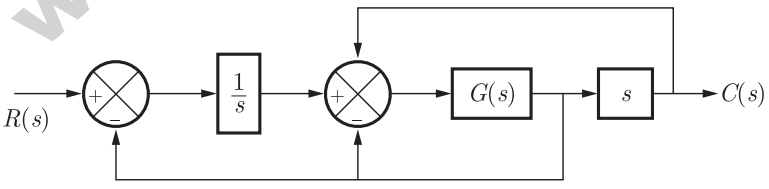
then $G(s)$ is

(A) 1 (B) s

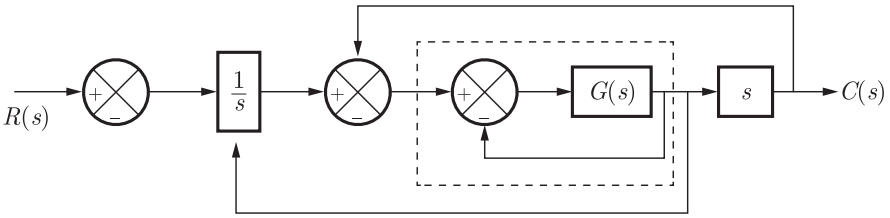
(C) $1/s$ (D) $\dfrac{-s}{s^3+s^2-s-2}$

Sol. 44 Correct option is (B).

We have the block diagram of given system as



By using minimization technique, we get



The closed loop transfer function for the dotted box is

$$\frac{G(s)}{1+G(s)}$$

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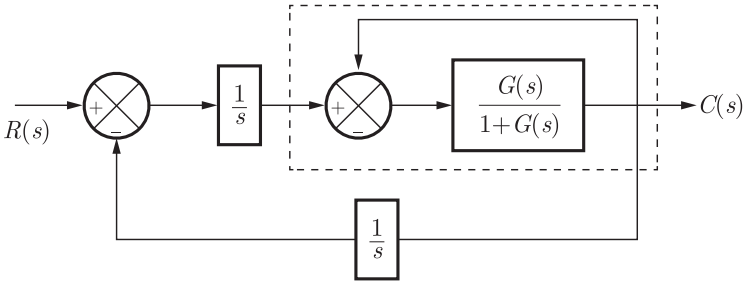
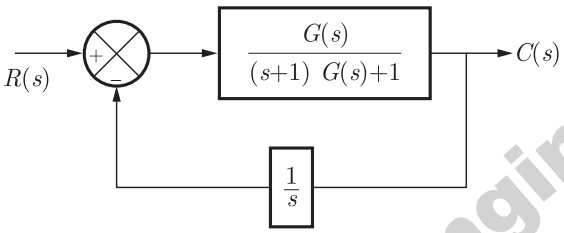


Again, we obtain the closed loop transfer function for the dotted box as

$$\frac{sG(s)}{(s+1)G(s)+1}$$

So, the block diagram reduces to



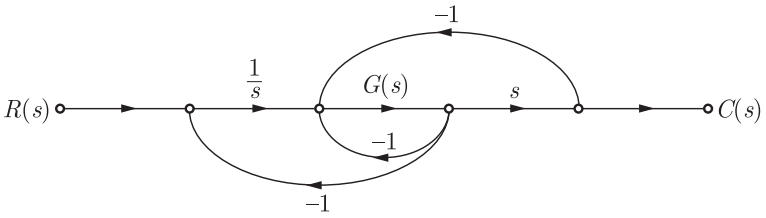
Thus, we have the overall transfer function as

$$\text{T.F.} \frac{\dfrac{G(s)}{(s+1)G(s)+1}}{\dfrac{(s^2+s)G(s)+s+G(s)}{s[(s+1)G(s)+1]}}$$

$$= \frac{sG(s)}{(s^2+s+1)G(s)+s}$$

ALTERNATIVE METHOD :

For the given block diagram, we draw the signal flow graph as



From the signal flow graph, we have forward paths

$$p_1 = \frac{1}{s}G(s)s = G(s)$$

and the closed loops

$$L_{11} = \frac{1}{s}G(s)(-1) = -\frac{G(s)}{s};$$

$$L_{12} = G(s)(-1) = -G(s);$$

and $$L_{13} = G(s)s(-1) = -sG(s)$$

So, the transfer function is obtained as

$$\text{T.F.} = \frac{p_1\Delta_1}{\Delta}$$

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$$= \frac{G(s)(1)}{1-\left[-\frac{G(s)}{s} - G(s) - sG(s)\right]}$$

$$\text{T.F.} = \frac{sG(s)}{s + G(s)(s^2+s+1)}$$

For any value of $G(s)$ given in the options, the desired system transfer function can not be achieved.

Q. 45 Consider the system described by following state space equations

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ -1 & -1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}0\\ 1\end{bmatrix}u; \quad y = \begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

If u is unit step input, then the steady state error of the system is

(A) 0 (B) 1/2

(C) 2/3 (D) 1

Sol. 45 Correct option is (A).

We have the state space equation,

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ -1 & -1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}0\\ 1\end{bmatrix}u$$

$$y = \begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

From the state-space equation, we obtain the matrices

$$A = \begin{bmatrix}0 & 1\\ -1 & -1\end{bmatrix}$$

$$B = \begin{bmatrix}0\\ 1\end{bmatrix}$$

$$C = \begin{bmatrix}1 & 0\end{bmatrix}$$

So, we obtain

$$[SI - A] = \begin{bmatrix}S & 0\\ 0 & S\end{bmatrix} - \begin{bmatrix}0 & 1\\ -1 & -1\end{bmatrix} = \begin{bmatrix}S & -1\\ 1 & S+1\end{bmatrix}$$

Therefore,

$$[SI - A]^{-1} = \frac{1}{S^2+S+1}\begin{bmatrix}S+1 & 1\\ -1 & S\end{bmatrix}$$

Hence, we obtain the transfer function of the system as

$$\text{T.F.} = C[SI - A]^{-1}B$$

$$= \begin{bmatrix}1 & 0\end{bmatrix}\frac{1}{S^2+S+1}\begin{bmatrix}S+1 & 1\\ -1 & S\end{bmatrix}\begin{bmatrix}0\\ 1\end{bmatrix}$$

$$= \frac{1}{S^2+S+1}\begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}1\\ S\end{bmatrix}$$

$$= \frac{1}{S^2+S+1}$$

This is the closed loop transfer function,

So we get

$$\frac{G(S)}{1+G(S)} = \frac{1}{S^2+S+1}$$

$$G(S) = \frac{1}{S^2+S}$$

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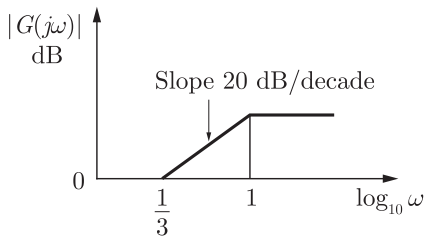
Thus, the steady state error for unit step input is

$$e_{SS} = \frac{1}{1 + \lim_{S \to 0} G(S)}$$

$$= \frac{1}{1 + \lim_{\delta \to 0} \frac{1}{\delta^2 + \delta}}$$

$$= \frac{1}{1 + \infty} = 0$$

Q. 46 The magnitude Bode plot of a network is shown in the figure



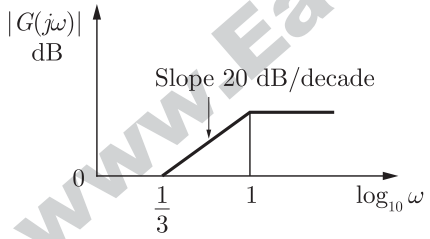
The maximum phase angle ϕ_m and the corresponding gain G_m respectively, are

(A) -30° and 1.73 dB (B) -30° and 4.77 dB

(C) $+30^\circ$ and 4.77 dB (D) $+30^\circ$ and 1.73 dB

Sol. 46 Correct option is (C).

Given the magnitude Bode plot,



Since, slope at 1/3 is increasing and slope at 1 is decreasing. So, we can write frequency response function as

$$G(j\omega) = \frac{\left(\frac{1}{3} + j\omega\right)}{(1 + j\omega)}$$

or $$G(j\omega) = \frac{\frac{1}{3}\left(1 + \frac{j\omega}{1/3}\right)}{(1 + j\omega)}$$

or $$G(j\omega) = \frac{\frac{a}{b}(1 + j\omega/a)}{(1 + j\omega/b)}$$

Therefore, the maximum phase angle is

$$\phi_m = 90^\circ - 2\tan^{-1}\left(\sqrt{a/b}\right)$$

$$= 90^\circ - 2\tan^{-1}(1/\sqrt{3})$$

$$= 90^\circ - 60^\circ = 30^\circ$$

and the maximum phase occur at

$$\omega = \sqrt{ab} = 1/\sqrt{3}$$

Thus, we obtain the gain at the frequency as

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$$G_m$$

$$= 20\log\left(\sqrt{\left(\frac{1}{\sqrt{3}}\right)^2+\left(\frac{1}{3}\right)^2}\right) - 20\log\left(1^2+\left(\frac{1}{\sqrt{3}}\right)^2\right)^{1/2}$$

$$= 4.76$$

Q. 47 A periodic waveform observed across a load is represented by

$$V(t) = \begin{cases} 1+\sin\omega t & 0 \le \omega t < 6\pi \\ -1+\sin\omega t & 6\pi \le \omega t < 12\pi \end{cases}$$

The measured value, using moving iron voltmeter connected across the load, is

(A) $\sqrt{\frac{3}{2}}$ (B) $\sqrt{\frac{2}{3}}$

(C) $\frac{3}{2}$ (D) $\frac{2}{3}$

Sol. 47 Correct option is (A).

Moving iron instrument gives rms value, so measured value of moving iron is rms of given function

$$v(t) = \begin{cases} 1+\sin\omega t & 0 \le \omega t \le 6\pi \\ -1+\sin\omega t & 6\pi \le \omega t \le 12\pi \end{cases}$$

So, we have

$$V_{rms} = \left[\frac{1}{12\pi}\left[\int_0^{6\pi}(1+\sin\omega t)^2 d(\omega t) + \int_{6\pi}^{12\pi}(-1+\sin\omega t)^2 d(\omega t)\right]\right]^{1/2}$$

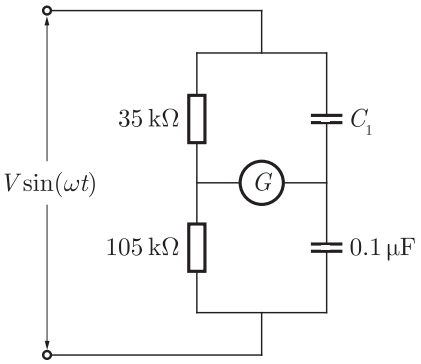
$$= \left[\frac{1}{12\pi}\left[\int_0^{6\pi}(1+2\sin\omega t+\sin^2\omega t)d(\omega t) + \int_{6\pi}^{12\pi}(1-2\sin\omega t+\sin^2\omega t)d(\omega t)\right]\right]^{1/2}$$

$$= \left[\frac{1}{12\pi}\left[6\pi+6\pi+\int_0^{6\pi}\frac{1-\cos 2\omega t}{2}d(\omega t) + \int_{6\pi}^{12\pi}\frac{1-\cos 2\omega t}{2}d(\omega t)\right]\right]^{1/2}$$

$$= \left[\frac{1}{12\pi}[12\pi+6\pi]\right]^{1/2}$$

$$= \left(\frac{18}{12}\right)^{1/2} = \sqrt{\frac{3}{2}}$$

Q. 48 In the bridge circuit shown, the capacitors are loss free. At balance, the value of capacitance C_1 in microfarad is _____.



Sol. 48 Correct answer is 0.3 μF.

Capacitor are lossless and bridge is balanced. On balancing, we have

$$z_1 z_4 = z_2 z_3$$

Now, the given bridge circuit is

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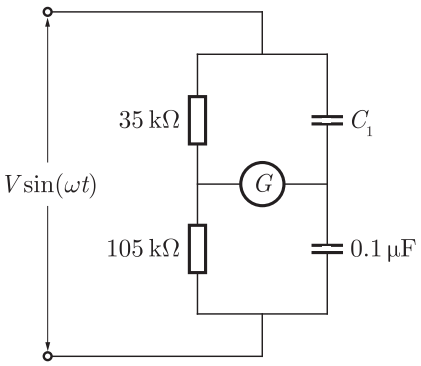
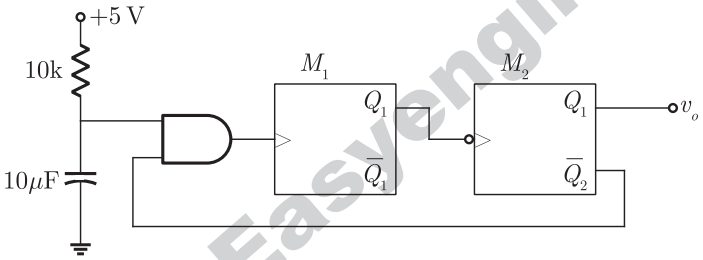


For balancing, we have

$$35 \times 10^3 \times \frac{1}{j\omega \times 0.1 \times 10^{-6}} = 105 \times 10^3 \times \frac{1}{j\omega \times C}$$

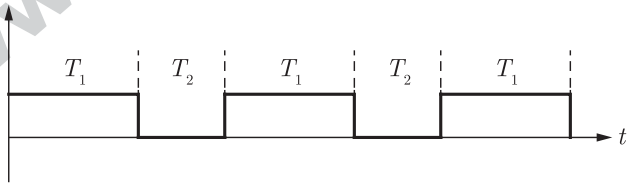
or $$C = 0.3\,\mu\text{F}$$

Q. 49 Two monoshot multivibrators, one positive edge triggered (M_1) and another negative edge triggered (M_2), are connected as shown in figure

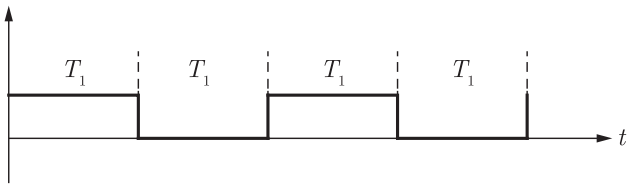


The monoshots M_1 and M_2 when triggered produce pulses of width T_1 and T_2 respectively, where $T_1 > T_2$. The steady state output voltage v_0 of the circuit is

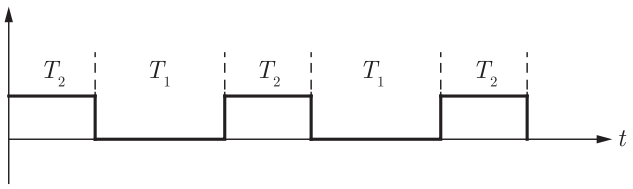
(A) v_o



(B) v_o



(C) v_o



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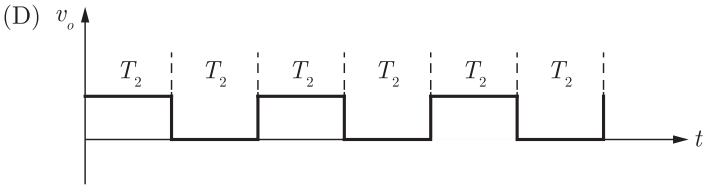
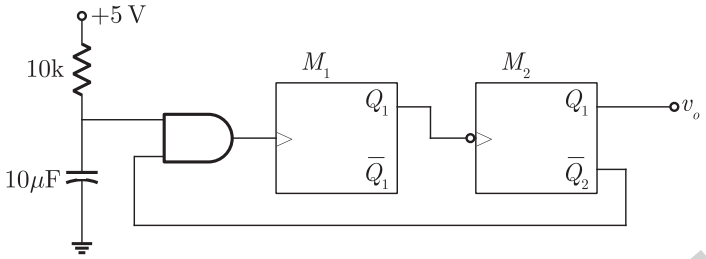
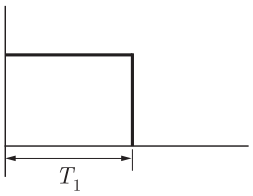
(D) 

Sol. 49 Correct option is (C).

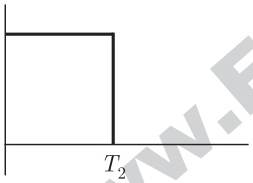
We have the multivibrators circuit as shown below



When monoshot multivibrator M_1 is triggered, it produces a pulse of T_1 duration.

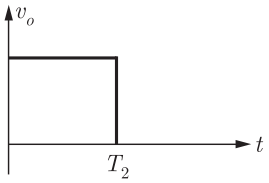


Similarly, when monoshot multivibrator M_2 is triggered, it produces a pulse of T_2 duration



Let, the output Q_2 is initially high.

So, the output v_o will be high for time period T_2.



For this period, $\overline{Q_2} = 0$

So, the output of AND gate is low. Since, M_1 is positive triggered. So, M_1 will be OFF for duration T_2.

After T_2 time,

$$Q_2 = 0$$

and

$$\overline{Q_2} = 1$$

So, the output of AND gate is 1; i.e. M_1 is triggered. Hence, output Q_1 is high for duration T_1. Since, M_2 is negative edge triggered, So M_2 will be off for the duration T_1 and hence, output v_o will be as

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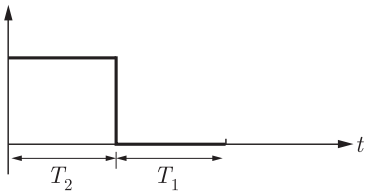
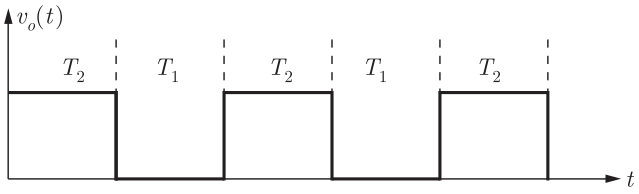
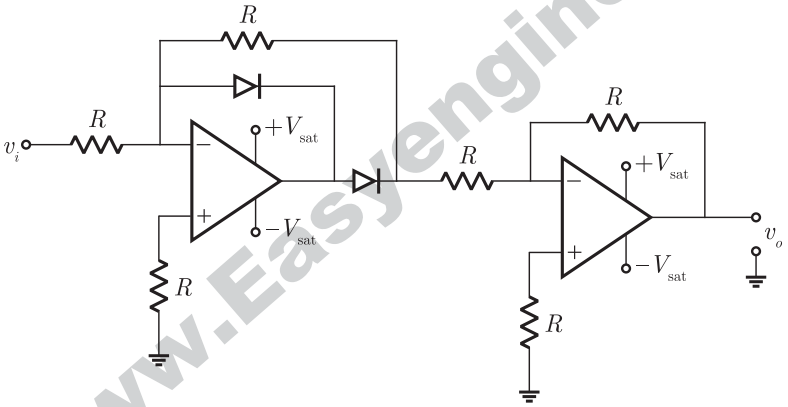


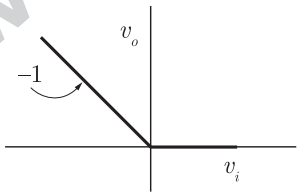
After T_1 time, the output Q_1 becomes low, and the M_2 gets ON (due to negative edge triggering). Hence, the output v_o again goes high for duration T_2. Thus, the complete output waveform is



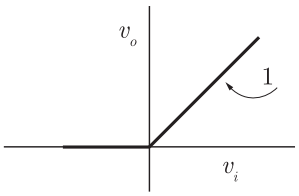
Q. 50 The transfer characteristic of the Op-amp circuit shown in figure is



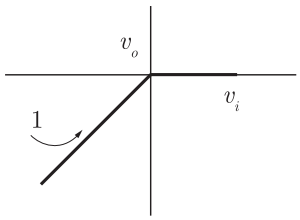
(A)



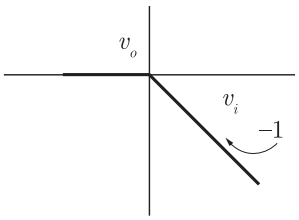
(B)



(C)



(D)



Sol. 50 Correct option is (C).

Given the op-amp circuit

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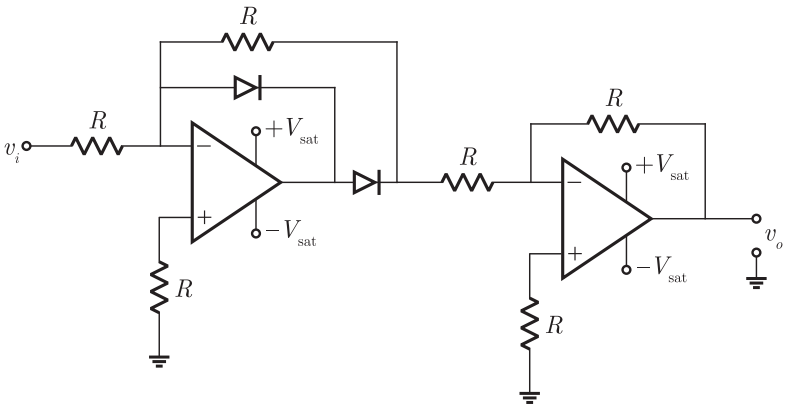


For the given circuit, we consider the following two cased.

Case I : when $v_i > 0$

For this case, the diode conducts. Since, the voltage at negative and positive terminals are same for ideal op-amp. So, for the 1st op-amp, we have

$$V_1^- = V_1^+ = 0$$

Therefore, the output of first op-amp is zero, which is applied to negative terminal of second op-amp.

Thus we get the output $v_o = 0$.

Case II : when $v_i < 0$

For this case, the diode is open and the output of first op-amp is

$$V_{o1} = -\frac{R}{R} v_i = -v_i$$

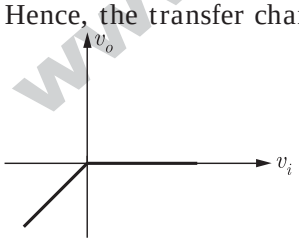
Therefore, the output of second op-amp is

$$v_o = -\frac{R}{R} v_{o1} = v_i$$

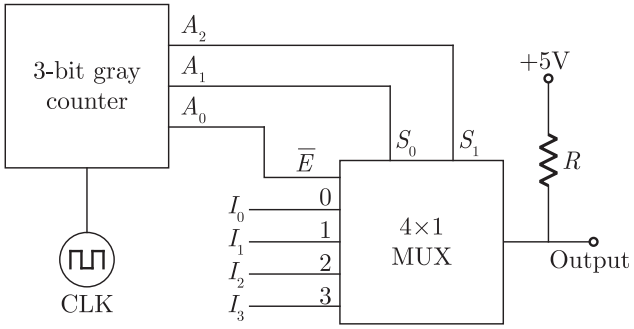
Thus, we have the output voltage

$$v_o = \begin{cases} 0 & v_i > 0 \\ v_i & v_i < 0 \end{cases}$$

Hence, the transfer characteristic of op-amp circuit is



Q. 51 A 3-bit gray counter is used to control the output of the multiplexer as shown in the figure. The initial state of the counter is 000_2. The output is pulled high. The output of the circuit follows the sequence



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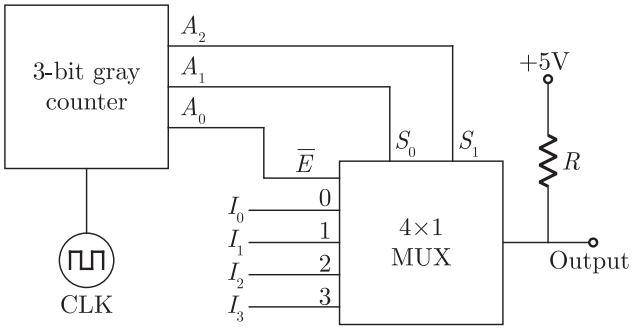
(A) I_0, 1, 1, I_1, I_3, 1, 1, I_2 (B) I_0, 1, I_1, 1, I_2, 1, I_3, 1

(C) 1, I_0, 1, I_1, I_2, 1, I_3, 1 (D) I_0, I_1, I_2, I_3, I_0, I_1, I_2, I_3

Sol. 51 Correct option is (A).

We have the given logic circuit



Initial state of gray counter is $(000)_2$. So, we have the outputs

$$A_0 = 0 \text{ and } A_1 = 0 \text{ and } A_2 = 0$$

For the enable input to multiplexer, we have

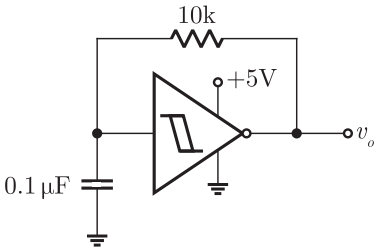
If $\overline{E} = 0$, then it will select any one of I_0, I_1, I_2, I_3.

If $\overline{E} = 1$, then it will be in high impedance state.

So, we get the output of multiplexer for the different inputs (output of 3-bit gray counter) as

Initial counter	output	
000	I_0	
001	1	(High impedance state)
011	1	(High impedance state)
010	I_1	
110	I_3	
111	1	(High impedance state)
101	1	(High impedance state)
100	I_2	

Q. 52 A hysteresis type TTL inverter is used to realize an oscillator in the circuit shown in the figure.



If the lower and upper trigger level voltages are 0.9 V and 1.7 V, the period (in ms), for which output is LOW, is _ _ _ _ _.

Sol. 52 Correct answer is 0.64 ms.

Given the oscillator circuit realiced using a hyteresis type TTL inverter as

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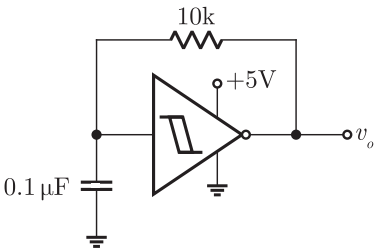


Also, we have the upper and lower trigger level voltages as

$$\text{UTL} = 1.7\text{ V}$$

$$\text{LTL} = 0.9\text{ V}$$

For the capacitor, the voltage across it, is given as

$$V_c(t) = V_c(\infty) + [V_c(0) - V_c(\infty)]e^{-t/RC}$$

For the given data, we have

$$V_c(0) = 1.7V$$

$$V_c(\infty) = 0\text{ V}$$

and $V_c(t) = 0.9$

So, we obtain the time t after which output triggers as

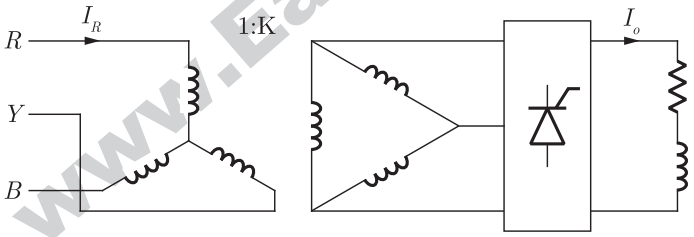
$$0.9 = 0 + [1.7 - 0]e^{-t/RC}$$

$$0.9 = 1.7e^{-t/(10\times10^3\times0.1\times10^{-6})}$$

$$t = 0.636 \times 10^{-3}\text{ sec}$$

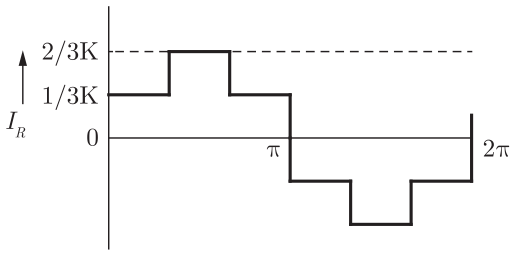
$$= 0.64\text{ ms}$$

Q. 53 A three-phase fully controlled bridge converter is fed through star-delta transformer as shown in the figure.



The converter is operated at a firing angle of 30°. Assuming the load current (I_0) to be virtually constant at 1 p.u. and transformer to be an ideal one, the input phase current waveform is

(A)



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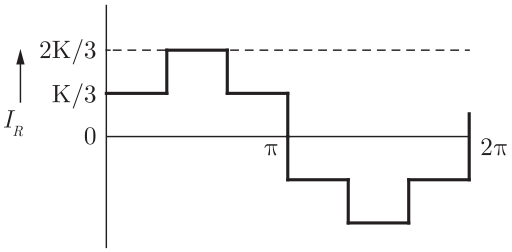
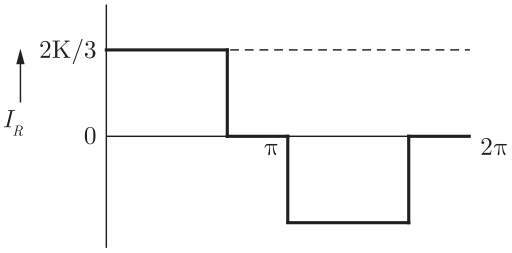
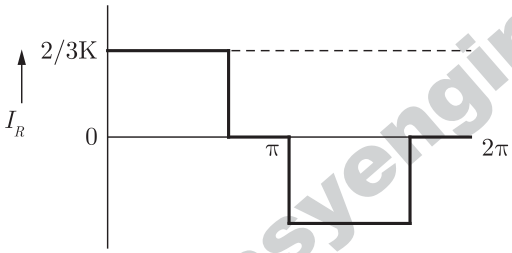
(B)



(C)

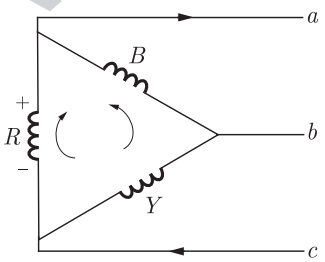


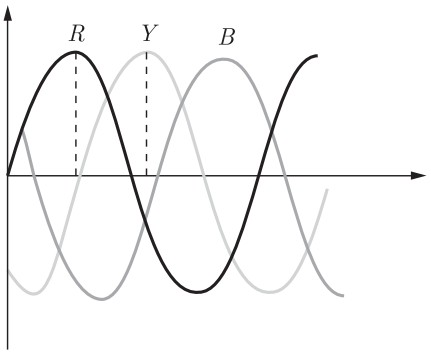
(D)



Sol. 53 Correct option is (B).

When R phase has maximum voltage at conducts and lines a and c conducts. The current are divided into R and YB winding.





current through $R = \frac{I_o \times 2R}{3R} = \frac{2I_o}{3}$

current through B and $Y = \frac{I_o}{3}$

Phase an conduct from 90° to 150°

$$I_o = \frac{2I}{3}$$

where B conducts,

current through R and $Y = \frac{I_o}{3}$

current through $B = \frac{2I_o}{3}$

The current through Δ-phase winding

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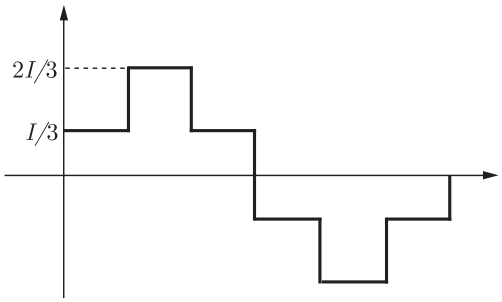
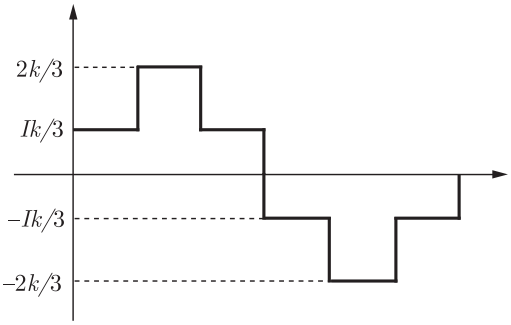
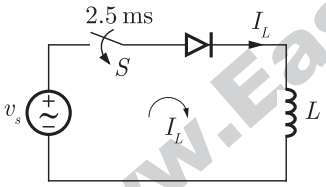


current through primary, $I_p = kI_s$

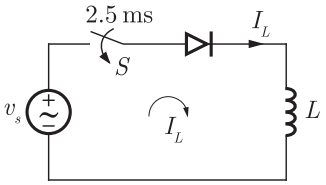


Q. 54 A diode circuit feeds an ideal inductor as shown in the figure. Given $v_s = 100\sin(\omega t)$ V, where $\omega = 100\pi$ rad/s, and $L = 31.83$ mH. The initial value of inductor current is zero. Switch S is closed at $t = 2.5$ ms. The peak value of inductor current i_L (in A) in the first cycle is _ _ _ _ _.



Sol. 54 Correct answer is 17.07 A.

We have the diode circuit as



Given parameters for the circuit are

$$\omega = 100\pi \text{ rad/s}$$
$$V_s = 100\sin(\omega t) \text{ V}$$
$$L = 31.83 \text{ mH} = 31.83 \times 10^{-3} \text{ H}$$

When switch is closed at $t = 2.5$ ms, we have

$$V_s - L\frac{dI}{dt} = 0 \text{ (in positive half cycle)}$$

or
$$V_s = L\frac{dI}{dt} \quad \text{...(i)}$$

For the current to be maximum, we have

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$$\frac{dI}{dt} = 0$$

or $V_s = 0$

So, $V_s = 100 \sin \omega t = 0$

or $\omega t = n\pi$

or $t = \frac{\pi}{100\pi} = 10 \text{ ms}$

Therefore, the current is obtained as

$$\frac{1}{L}\int_{t_1}^{t_2} V_s dt = \int_0^I dI$$

or
$$I = \frac{1}{L}\int_{2.5 \text{ ms}}^{10 \text{ ms}} V_s dt$$

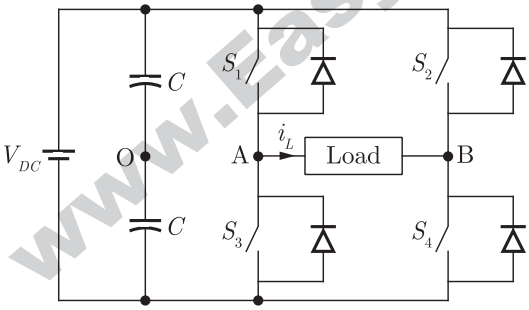
$$= \frac{1}{31.83 \times 10^{-3}} \int_{2.5 \text{ ms}}^{10 \text{ ms}} 100 \sin \omega t + d(\omega t)$$

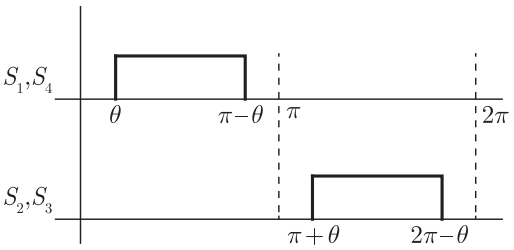
$$= \frac{1}{31.83 \times 10^{-3}} \times 100 \left[-\frac{\cos \omega t}{\omega} \right]_{t=2.5 \text{ ms}}^{t=10 \text{ ms}}$$

$$= \left(\frac{1}{\sqrt{2}} + 1 \right) \times \frac{100}{100\pi} \times \frac{1}{31.83 \times 10^{-3}}$$

$$= 17.07 \text{ A}$$

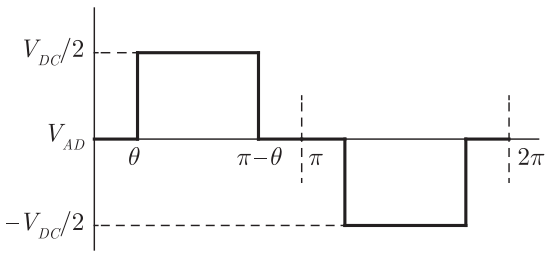
Q. 55 A single-phase voltage source inverter shown in figure is feeding power to a load. The triggering pulses of the devices are also shown in the figure.





If the load current is sinusoidal and is zero at 0, π, 2π...., the node voltage V_{AO} has the waveform

(A)



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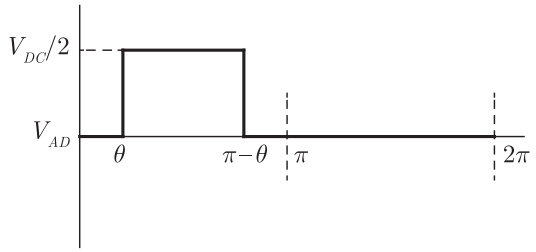
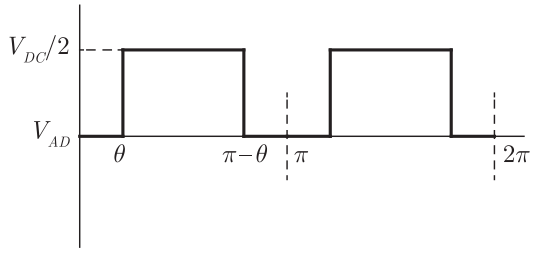
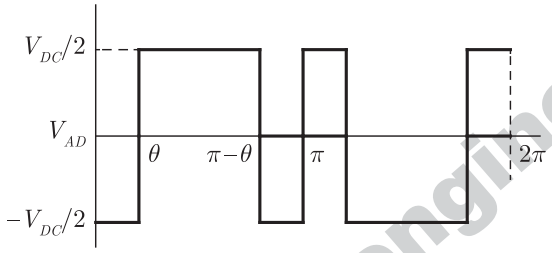
(B)



(C)



(D)



Sol. 55 Correct option is (D).

It is given that load current is sinusoidal, so continuous conduction.

when $S1$ is off from 0 to θ, diode parallel to 53 conducts and $V_{AO} = -\frac{V_{DC}}{2}$

from $\theta < angle < (\pi - \theta)$, $S1$ conducts $V_{AO} = \frac{V_{OC}}{2}$

Again from $(\pi - \theta)$ to (θ), diode conducts and $V_{AO} = -\frac{V_{DC}}{2}$

END OF THE QUESTION PAPER

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ANSWER KEY

General Aptitude									
1	2	3	4	5	6	7	8	9	10
(D)	(C)	(C)	(C)	(C)	(B)	(D)	(D)	(C)	(C)

Electrical Engineering									
1	2	3	4	5	6	7	8	9	10
(C)	(2)	(A)	(0.4-0.5)	(C)	(C)	(A)	(A)	(A)	(14)
11	12	13	14	15	16	17	18	19	20
(D)	(C)	(12.45-12.65)	(A)	(B)	(332)	(C)	(A)	(2)	(A)
21	22	23	24	25	26	27	28	29	30
(D)	(D)	(C)	(C)	(B)	(C)	(D)	(0.05-0.07)	(2)	(3)
31	32	33	34	35	36	37	38	39	40
(B)	(B)	(D)	(C)	(B)	(B)	(32.4-34.0)	(879-881)	(23-24)	(B)
41	42	43	44	45	46	47	48	49	50
(186-188)	(0.75)	(0.22-0.24)	(B)	(A)	(C)	(A)	(0.3)	(C)	(C)
51	52	53	54	55					
(A)	(0.62-0.66)	(B)	(16.6-17.4)	(D)					

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